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Th. H. Handbury
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A

MANUAL

OF

PRACTICAL MILITARY ENGINEERING,

PREPARED FOR THE USE OF THE CADETS OF THE U. S. MILITARY ACADEMY, AND FOR ENGINEER TROOPS.

BY

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PREFACE.

It is impossible, in a book of this character, to give to each person the credit belonging to him for any particular method or rule. Like a work on mathematics, it is the growth of time, and most of the sources whence its matter is derived are themselves compilations. The most prominent of these is the admirable work on Military Engineering, issued from the English School of Practice at Chatham, in 1870. Some of the other sources are the English and French Aides-Mémoire; Duane's Manual for Engineer Troops; Tielke's, Macaulay's, and Mahan's Field Fortification; Frome's, Chatelain's, and Maes' works on Topography; and the practice of the U. S. Engineer Battalion. Material has also been taken from military writers upon the War of the Rebellion, their names being quoted in the body of the work. The latter has been done whenever the credit could be fixed upon an individual.

Though prepared for a specific purpose, it is hoped that this volume may be found useful to officers of the army at large.

O. H. E.

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MILITARY MINING.

PART I.—MILITARY MINING.

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SECTION I.—DRIVING GALLERIES, ETC.

DEFINITIONS—TOOLS—MINING WITH FRAMES AND SHEETING—MINING WITH CASES—VENTILATION OF MINES—LIGHTING OF MINES—TIME REQUIRED FOR MINING.

DEFINITIONS.

1. **Military Mine.**—A mine is in general terms any subterranean passage. The object of a military mine is usually to place a quantity of powder, the explosion of which is to blow up the ground above it, and the term is generally employed to designate the charge as well as the passage leading to it.

Chamber.—The receptacle for the powder is called the chamber.

Shaft—Gallery—Branch—Ascending and Descending Galleries.—The subterranean passage is called a shaft when it is vertical, a gallery when it is horizontal or inclined, and exceeds in dimensions $3' \times 4'$, and a branch when it is under these dimensions. When a gallery or branch is inclined, it is called ascending or descending according to the direction of its inclination.

2. **Description of Linings.**—As the military miner generally works in loose or made soil, he has to support, as he advances, the top and sides of his excavation with wooden linings. These are of two kinds, viz., frames and sheeting, and cases.

Frames and Sheeting.—To make the lining with frames and sheeting, stout frames are placed at intervals, and outside them sufficient sheeting planks to prevent the earth falling into

the gallery or shaft. The distance apart of the frames depends upon the strength and thickness of the sheeting; the number of pieces of sheeting used varies with the tenacity of the soil.

Cases.—The other description of lining is with cases, consisting of four pieces of plank, which are placed touching each other, so as to form a continuous lining.

Groundsills, Capsills, and Stanchions.—In both kinds the pieces laid on the ground are called groundsills, the upper pieces capsills, and the side pieces stanchions.

3. **Names and Dimensions of Galleries.**—The following table gives the names and dimensions of galleries employed in mining operations:

NAME.	Dimensions in the clear.	SCANTLING OF FRAMES.		
		Groundsill.	Stanchion.	Capsill.
	Height. Width.			
1. Great Gallery....	6′ 6″ × 7′ 0″	6″×3″	6″×6″	6″×8½″
2. Principal Gallery.	6′ 6″ × 3′ 6″	5½″×3″	5½″×5½″	5½″×8″
3. Common Gallery.	4′ 6″ × 3′ 0″	5″×3″	5″×5″	5″×6½″
4. Branch	3′ 6″ × 2′ 6″	4″×3″	4″×4″	4″×5″

Application of the Different Kinds.—Number 1 is used for the descent into the ditch and the passage of cannon.

Number 2 for the descent into the ditch and the passage of troops two abreast.

Number 3 is sufficiently large for all the general purposes of the attack, and as it allows the miner a free change of posture, either to work kneeling on both knees, or on one knee with one foot advanced, he works without feeling cramped and executes this size more rapidly than any other.

Number 4 is too small to work in for a greater distance than ten or twelve feet.

TOOLS.

4. **Tools.**—The tools required in mining are:

Pickaxe (common).
" (short handle).
Shovel (common).
" (short handle).
Push Pick (Fig. 1).
Rake (Fig. 2).
Bucket (Figs. 3 and 4).
Windlass (Fig. 5).
Rope (2-inch).
Rope Ladder.
Wooden Wedges.
Wooden Pickets.
Miner's Wagon (Fig. 6).
Wheelbarrow.
Iron Candlestick (Fig. 7).
Lamp (miner's).
Lantern.
Oil Can.
Measuring Tape.
Compass.
Universal Level (Fig. 8).
Handsaw.
Mallet.
Hammer (claw).
Rough Plane (½-inch).
Chisel.
Gimlet.
Two-foot Rule.
Plumb-bob.
Boring Rods.
Five-foot Rod.
Miner's Bellows (Fig. 9).
Ventilating Tube.
Flexible Joints.
Needles, Thread, and Scissors.
Calico for Hose.
Hatchet.
Tin Funnel (for filling hose).
Rammers (short handled).
Spare Helves.
Sand-bags.

5. **Use of Some of the Tools.**—The push pick (Fig. 1) is used for loosening the earth in the recesses behind the cases previously to getting in a new case.

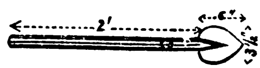


Fig. 1. Push Pick.

The miner's wagon (Fig. 6) is used for drawing earth from the face of the gallery to the bottom of the shaft, the earth being raised to the surface either in the truck or in a bucket.

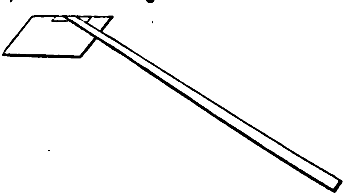


Fig 2. Rake.

The bucket may be made

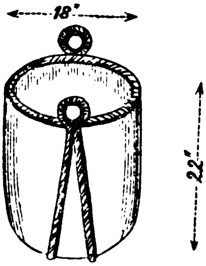


Fig. 3. Canvas Bucket.

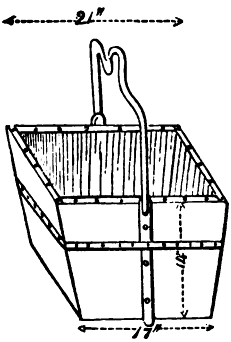


Fig. 4. Mining Bucket.

of canvas (Fig. 3), or of wood (Fig. 4). It may be raised by two ropes drawn by two men standing on opposite sides of the entrance, so as to clear the sides of the shaft, or by a windlass and rope (Fig. 5). The latter is more convenient and should be used, unless the shaft is very shallow.

To work the miner's bellows (Fig. 9) a man stands on the lower handles and works the vertical rod with his hands. The air tubes are attached to a nozzle at the bottom, whence they are led down the shaft as required. The tubes are made 1¼ inches in diameter, and in lengths of 2½ feet, all sharp turns being made by means of flexible tubing of sewed leather in lengths of 1 foot. Gutta-percha tubing, lined with a spiral wire similar to the diver's air pipe, is more convenient, and when large fans are used canvas hose with metal joints is required.

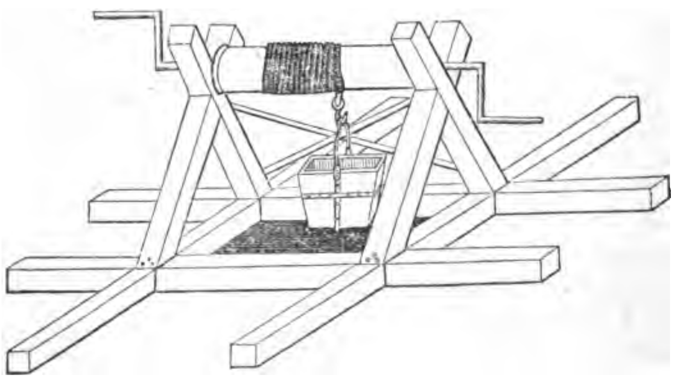
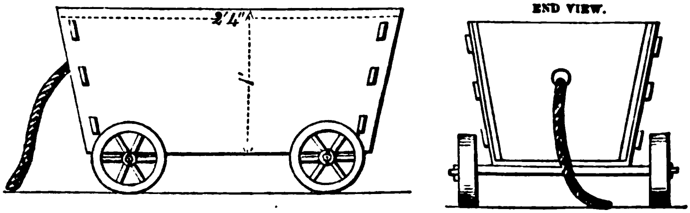
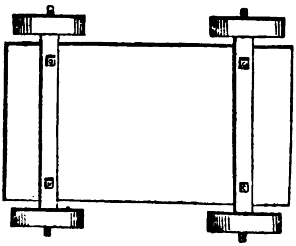


Fig. 5. Windlass.



INVERTED PLAN OF WAGON. Fig. 6. Miner's Wagon.



In shafts lined with frames and sheeting, a rope ladder with wooden rounds is used, secured at the top by two pickets driven about 1' away from the shaft, sloping outwards, and a third at a point where the two ropes meet together.

6. **Cutting out Wedges.**—The wedges are cut from right prisms of wood 8 or 10 inches high, with square bases, the sides of which are 4 or 5 inches long, by a diagonal saw cut.

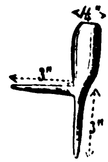


Fig. 7. Iron Candlestick.

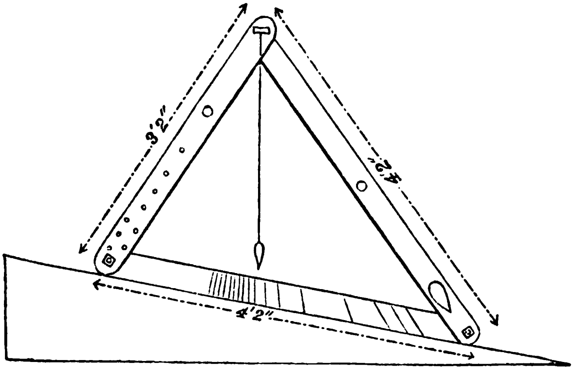


Fig. 8. Universal Level.

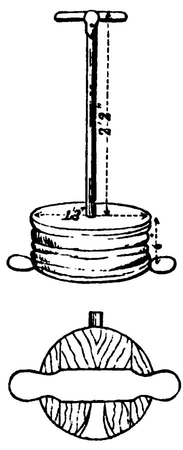


Fig. 9. Miner's Bellows.

MINING WITH FRAMES AND SHEETING.

7. **Shaft Frames.**—Shaft frames (Fig. 10) are composed of four pieces halved together. The top frame (Fig. 11) has the same dimensions in the clear as the others, but the ends project about 1′ in each direction, to keep it from falling down the shaft. The opposite pieces of each frame are marked with a saw cut, termed a score, at their middle on the upper side. The scores serve to fix the position which the frame should occupy when laid.

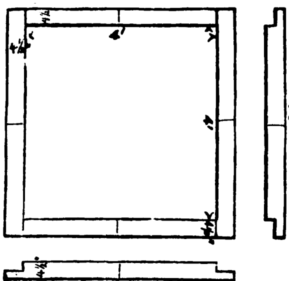


Fig. 10.

When the object is to drive a gallery from the bottom of the shaft, the width of the shaft frames in the clear must be at least equal to that of the gallery measured from out to out of its sheeting. A shaft sunk for es-

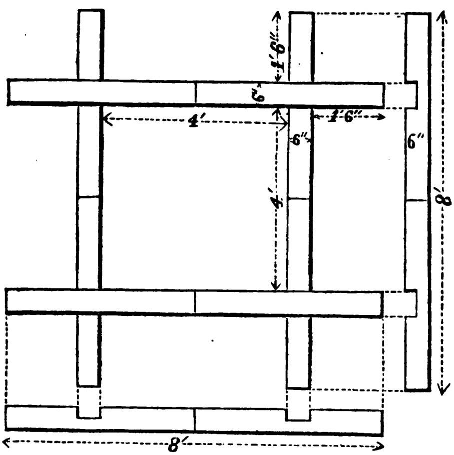


Fig. 11.

tablishing a mine-chamber simply should usually be of the least dimensions, say $2' \times 3'$.

8. **Sheeting.**—The sheeting of shafts should be of plank, 1″ to 1½″ thick and 11″ wide, cut into lengths of 5′. The planks are usually bevelled off for about 6″, thus admitting of the frames being placed at about 4-feet intervals.

9. **Working Party for Sinking Shaft.**—The working party required to sink a shaft and drive the first 4′ of gallery consists of 1 non-commissioned officer and 6 privates (8 when the windlass is used). They are disposed as follows: one man excavates and fills the bucket, being relieved when he has excavated 2′; two men haul up, or four men work the windlass; one man fills the wheelbarrow; one man wheels; and one man spreads, to prevent an accumulation of soil which might attract notice.

10. **Tools for Sinking Shaft.**—The tools required are: 1 short pick, 1 push pick, 2 long shovels, 2 short shovels, 1 line, 1 level, 1 measuring rod, 1 mallet, 1 bucket (of canvas or wood), 1 rope ladder, 2 wheelbarrows, 1 windlass. Two gauges or rods for the extreme dimensions of the rectangle of excavation are to be provided. These two rods must exceed respectively the true exterior dimensions of the shaft frames in length by about 6″, in order to admit of two thicknesses of sheeting planks being introduced all round, between the frame and sides of the excavation.

11. **Distance between Frames.**—The distance at which the floor of the gallery is to be placed below the surface of the ground being given, the first thing to be done is to determine the distance to be left between the frames. To find this, let us suppose that a common gallery, 4′ 6″ high in the clear, is to be driven from the bottom of a shaft 25′ deep. Then the height of

the gallery from the floor to the top of the capsill being..	5′ 1″
Thickness of top sheeting..	2″
Free space for introduction of sheeting	2″
Thickness of shaft frame next above gallery................	4½″
Total...	5′ 9½″

The top, therefore, of the frame above the gallery must be 5′ 9½″ from the bottom of the shaft. Subtract this from 25′, there remains 19′ 2½″. There would then be required four intervals of 4′ each, and one of 3′ 2½″ for the last.

To find the length of the last set of sheeting planks, the thickness of one frame and one overlap of 2″ must be added to 5′ 9½″, making 6′ 4″.

12. **Laying Out the Work.**—The work is laid out by first driving a picket to mark the axis of the shaft, and then two others, one on each side of the first and 3 or 4 yards from it, which with the first should be in the vertical plane containing the axis of the gallery which is to debouch from the bottom of the shaft. The rectangle of excavation is then marked upon the ground, its sides being 3″ shorter than the gauges; care being taken to have two of its sides parallel to the direction of the proposed gallery.

13. **Execution of a Shaft.**—An excavation is then cut vertically down to the depth of two or three feet, after which the top shaft frame is placed directly over the excavation. This frame is laid horizontal and flush with the surface of the ground, the latter being suitably prepared to receive it. The pieces are accurately laid, two of them being parallel to the direction of the gallery, and are confined by pickets, one at the end of each piece; care being taken to drive the two pickets of each piece at the same time, so that their true position may be kept.

The excavation is then continued to the depth of 4′, when a common frame is put together and laid horizontal at the bottom of the excavation, with its corresponding sides vertically under those of the upper frame. It is adjusted by means of its scores, the plumb-bob, and the level. The sheeting planks are then pushed down, bevelled faces outwards (Fig. 12). At top each of these planks is pressed home close to the top frame, but at the bottom it is kept out from the lower frame by wedges rather thicker

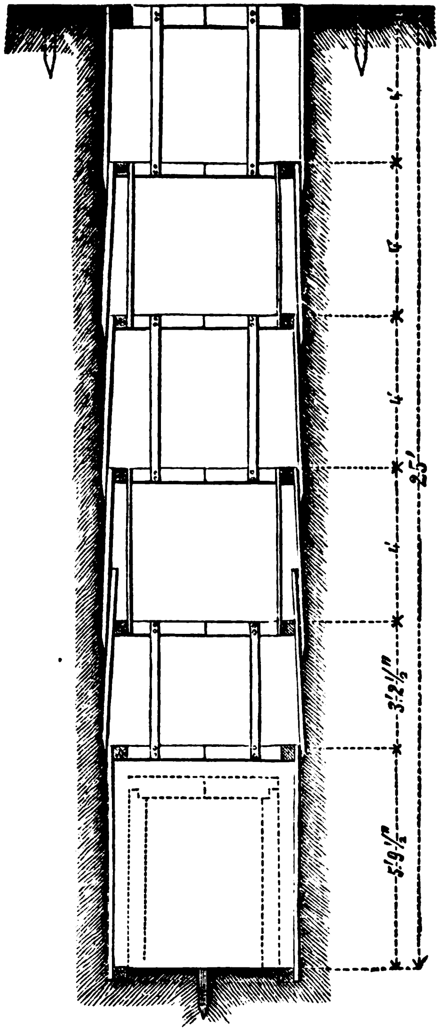


Fig. 12.—Shaft.

than the plank itself. After placing each frame, it must be supported in position by nailing wooden battens to it and to the frame above, or by passing a rope through a hole in each side of the frame, and putting a toggle through the rope.

After the first two shaft frames and one set of sheeting planks are thus placed, and the frames connected, the excavation is continued about 4′ deeper, when another frame is placed with the same care. A second set of planks is then introduced between the first set and the second frame, after removing the wedges which were before inserted. These new planks are pushed down to the bottom of the shaft, and are there wedged out from the lower frame as before.

The shaft is thus proceeded with, the gauge rods being constantly used to see that the extreme dimensions are not exceeded, until the miner arrives near the top of the proposed gallery, when the last shaft frame must be placed at the calculated interval. This being attended to, the excavation is continued to the level of the floor of the gallery, and a frame placed at the bottom of the shaft, leaving room for a single thickness only of sheeting around it; this sheeting, as before shown, must be 6′ 4″ long, and is placed only on three sides of the shaft, leaving that side clear on which the gallery is to be commenced.

Two breadths of sheeting are usually sufficient for each side of a shaft.

14. **Shaft in Bad Soil.**—In bad soil, however, the shaft must be lined throughout, and it may be necessary to provide a temporary intermediate support for the sheeting during the operation of sinking the interval. For this purpose a *false frame* is employed. It differs from the ordinary shaft frame in being a little larger from out to out. After the excavation has been carried about 2′ below the frame last placed (the sheeting having been driven down as fast as the excavation advanced), the false frame is placed in the same manner as the ordinary frame, with the exception that no wedges are driven between it

and the sheeting; it is connected by battens with the frame above. The excavation is then continued until the full depth of the interval is attained, when an ordinary frame is placed, the wedges driven, and the false frame removed.

When the gallery to be driven from the bottom is to be great or principal, the sheeting must be driven on all four sides, instead of three, and an additional frame must be placed 3′ above the bottom.

15. Commencing a Gallery from the bottom of a Shaft. —A common gallery frame is shown in Fig 13.

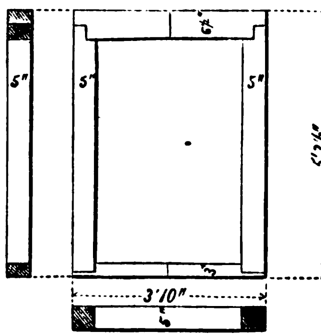


Fig. 13.—Common Gallery Frame.

The centre line of the gallery is marked at the bottom of the shaft on the woodwork, or by pickets, their position being determined by a plummet let down from two points of a straight edge placed over the mouth of the shaft, in the proper direction.

Two gauge rods are provided, that for the height 3″ greater than the outside dimensions of the frame, so as to allow of two thicknesses of sheeting plank being driven above the capsill; and that for the width to allow of four thicknesses of plank, two on each side of the frame. This last gauge must be marked in a conspicuous manner in the centre.

In commencing the gallery, the excavation may be carried forward one or two feet before the first frame is placed. The exact position of the first frame being determined, the groundsill is imbedded in the ground, outside and against the lower shaft frame. The stanchions are inserted, and the capsill set, and the whole frame squared by means of a plumb-bob, and temporarily secured in place by battens. (Fig. 14.) This being completed, the excavation is continued for a distance of 4′,

when another frame is set up. The groundsill is first placed exactly perpendicular to, and its score in the axis of, the gallery. The latter is effected by stretching a line over the two pickets or fixed points before determined. If the gallery is to be horizontal, the position of this sill will be verified by a spirit level and straight edge. The stanchions are then set up, their lower ends inserted in the notches in the groundsill. The capsill is placed, and its position verified by plumbings from

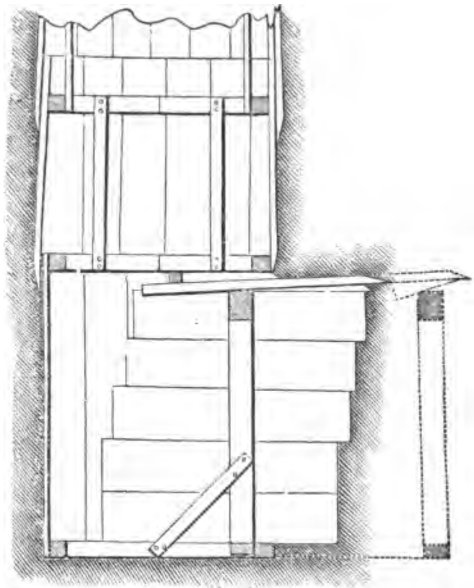


Fig. 14.—Commencing Gallery.

its score to that in the groundsill. The top sheeting planks having been introduced over the first frame, their bevelled faces upwards, are now pushed forward until they rest upon the capsill of the second frame. Wedges are then introduced, as in sinking a shaft, and the side sheeting is pushed on in an exactly similar manner.

16. Inclined Galleries.—An inclined gallery is executed in a similar manner to a horizontal one, the inclination being

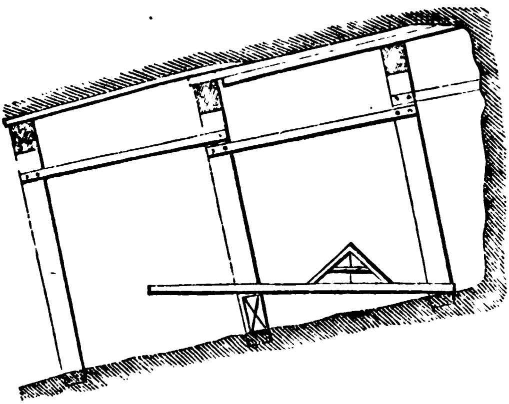


Fig. 15.—Use of Slope-Block.

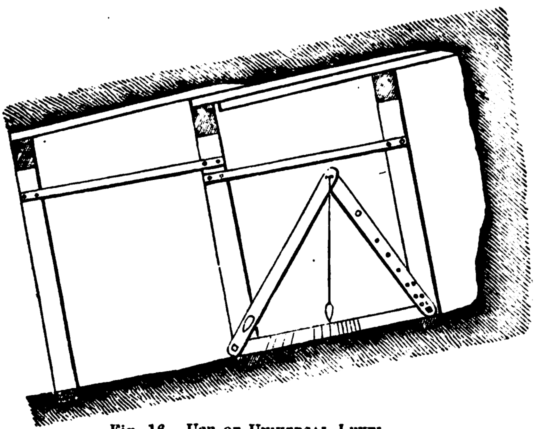


Fig. 16.—Use of Universal Level.

verified by means of a slope-block used in connection with a straight edge and spirit level (Fig. 15), or by the universal level (Fig. 16). The slope-block is a block whose thickness is

equal to the rise or fall of the floor of the gallery in a distance equal to one interval. To avoid mistake, it is desirable that this block should be cubical.

The stanchions are placed at right angles to the slope, which should not exceed one on two.* The distance between the frames is measured along the slope, so that the same sheeting answers for both horizontal and inclined galleries. On first placing the frames, the stanchions should be set a little more backward at the top than the proper angle of inclination would place them; for in driving the sheeting, they will afterwards be forced forward an inch or two.

When a descending gallery is commenced from a parallel, the trench of the parallel must be deepened as much as may be necessary to allow the top of the excavation of the gallery to be 3′ below the original surface of the ground. (Fig. 17.)

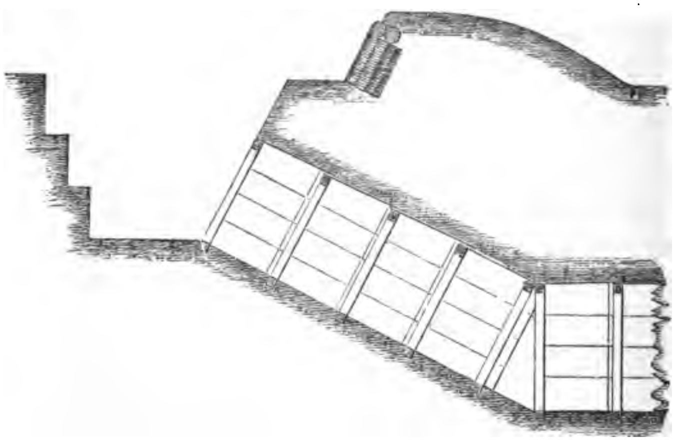


Fig. 17.—Changing from Descending to Horizontal Direction.

The drawing shows the manner of placing the first vertical frame, in changing from a descending direction to a horizontal one.

* See par. 262.

17. **Modification of the foregoing Method in Ordinary Soil.**—Although it has been thought desirable to describe the mode of driving a gallery under circumstances which render it necessary to close-sheet the top and sides, it will, in most instances, be found sufficient (except in the case of great galleries) to sheet only the top. When this is the case, the stanchions of the frames are let into grooves cut in the sides, and thereby a considerable amount of excavation will be saved.

18. **Working Party for Driving a Gallery.**—The party required to drive a gallery consists of 1 non-commissioned officer and 9 privates (11 when the windlass is used). They are disposed as follows: one man picks; one fills the truck; one wheels; one fills the bucket at the bottom of the shaft, or attaches the truck itself to the windlass; five or seven men are employed at the top of the shaft as before. After the gallery has advanced 20′, an additional man and truck will be required, and so on for every 20′. One additional man will also be required at top to work the ventilating apparatus, when that becomes necessary.

Instead of using a bucket for hoisting up the earth, it is more expeditious to attach the full truck to the windlass. In great galleries the earth may be removed in wheelbarrows.

19. **Tools for Driving a Gallery.**—The tools required are the same as for the shaft, with the addition of the trucks and ventilating apparatus.

20. **Driving a Gallery in Bad Soil.**—When there appears to be danger of the soil falling in, the sheeting must be introduced as soon as possible, without waiting for another frame, and pushed forward as the man excavates, so that he may always be under cover. When it is required to do this for a greater distance than a foot or two, a temporary frame, called a false frame, is used to support the projecting ends of the top sheeting. This consists (Fig. 18) of a groundsill, two stanchions, and a capsill, united by mortise and tenons; the cap is rounded

on top; the height is the same as the gallery frame; the width 2″ greater. It is placed in the axis of the gallery, 2′ from the last frame, and in such a manner that the capsill shall be 2″ higher than those of the ordinary frames, to allow the sheeting, when driven forward, to have the proper splay upwards without wedges, which cannot be used with the false frame. The excavation is then pushed on until the place for the second gallery frame is reached. This is set up, and the wedges driven in the usual manner, and the false frame is removed.

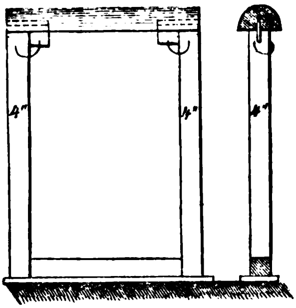


Fig. 18.—False Frame.

21. Commencing a Gallery in Bad Soil.—To commence the gallery in such soil, set up the first frame, and secure it in place by battens (Fig. 19). Drive down the sheeting that is opposite the capsill until sufficient space is gained to introduce the top sheeting of the gallery. As soon as this sheeting is entered, in order to prevent the pressure of the earth from forcing down the forward ends, a piece of plank is laid over the rear ends, and engaged under the shaft frame directly above. Then force down the shaft

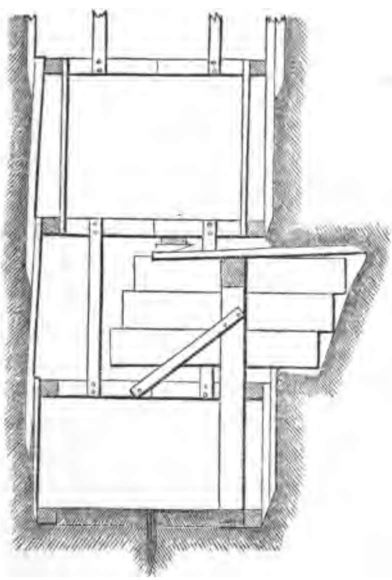


Fig 19.—Commencing Gallery in Bad Soil.

sheeting one foot further, and enter the upper course of side sheeting. Continue to introduce the side sheeting planks by pairs, forcing down for this purpose the shaft sheeting one foot at a time. On reaching the intermediate shaft frame, knock out the side which is against the gallery, and remove the sheeting resting against it. Insert all the side sheeting, and push the excavation forward, always driving the sheeting in advance.

22. **Returns.**—Galleries about 3′ long, called returns, should be broken out at right angles to, and at intervals of 30′ along, the main gallery, for the reception of the empty trucks going up to its face, while the loaded trucks pass them.

23. **Branches from a Gallery.**—A branch may be excavated in the same direction with, and in continuation of, a gallery. In this case, the first branch frame must be placed immediately beyond the last gallery frame and close to it; or if there be room, it may be placed exactly within it.

It may be cut at right angles to the gallery, in which case it is commenced in the same manner as the gallery itself from the bottom of a shaft.

It may be commenced obliquely from the side of a gallery. In this case, if the soil be good and not wanting much support, the first branch frame is placed as near to the side of the gallery as possible (allowance being made for the side sheeting of the branch), but at right angles to the new direction. If the ground cannot be trusted, the first branch frame must be placed in line with the side of the gallery itself (Fig.

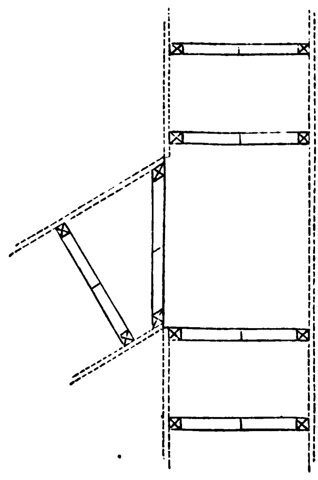


Fig. 20.—Oblique Return in Bad Soil.

20), and consequently a longer capsill and groundsill than the ordinary ones will be necessary. If the axis of the branch makes an angle less than 45° with that of the gallery, this

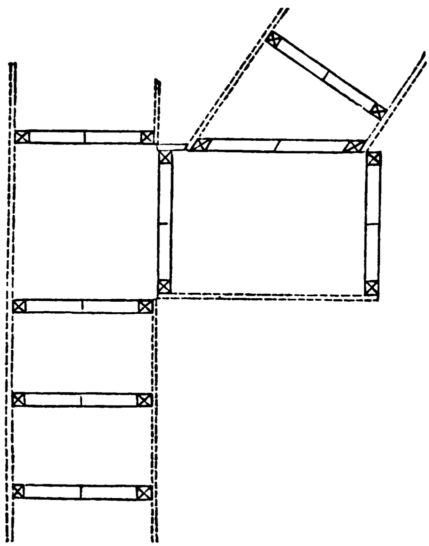


Fig. 21 —Very Oblique Return.

capsill would be too long for a proper stiffness. In that case, a short rectangular return must first be made, as shown in Fig. 21.

MINING WITH CASES.

24. **Mining Cases.**—A mining case consists of four pieces—two stanchions, a capsill, and a groundsill. For ordinary work they are made of 2″ plank, and have a $\frac{3}{8}''$ round iron bolt driven transversely through them about $4\frac{1}{2}$ inches from each end, to prevent them from splitting. The stanchions (Fig. 22) have tenons 2″ long by 3″ wide at each end, and mortises of corresponding dimensions are cut in the ends of the capsill and

groundsill to receive the tenons; the most convenient width is 12″, but it may be less.

In great galleries, the stanchions may be 4″ thick, the groundsill 3″, and the capsill 5″.

Notches, as shown in the figure, are cut in the stanchions for the purpose of rendering them more manageable, both in putting them up and taking them down. They also serve for places in which to drive pickets to support the case in a descending gallery

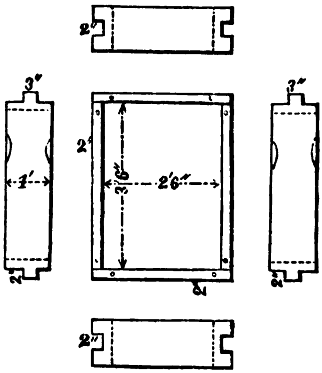


Fig. 22.—Mining Cases.

The size in the clear of cases, both for shafts and galleries, is the same as that of frames, and the same precautions and arrangements in their adjustments are necessary.

25. **Sinking a Shaft.**—The first case is laid together on the ground, in the position of the proposed shaft, with its longer sides parallel to the direction of the gallery that is to be driven, and its centre line coinciding with the centre of that gallery. The ground is then marked round the case, which is removed, and the earth within that space excavated to a depth of 1′. The case is then placed in the excavation with its upper edge level with the ground, and earth rammed in all round its sides.

In placing each succeeding case, the ground must be excavated for one end first, then for one side, next for the other end, and lastly for the remaining side, placing each piece singly, and cutting away no more earth than necessary. But in order that the side to be placed last

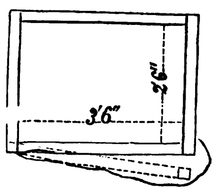


Fig. 23.—Recess Behind Case.

may be got in, it is necessary to cut away behind it a wedge-shaped recess (Fig. 23), into which it may be pushed, and then drawn forward to its proper position, with the tenon of the end piece in its mortise. The earth remaining in the middle is then excavated, and the next case got in, in the same manner, taking care to make the wedge-shaped recesses on opposite sides of the shaft, as otherwise there would be a hollow behind the cases all down one side. It is advisable to fill up these spaces with sods, etc., pushed up from below. The cases must all be flush with one another on the inside, and close together.

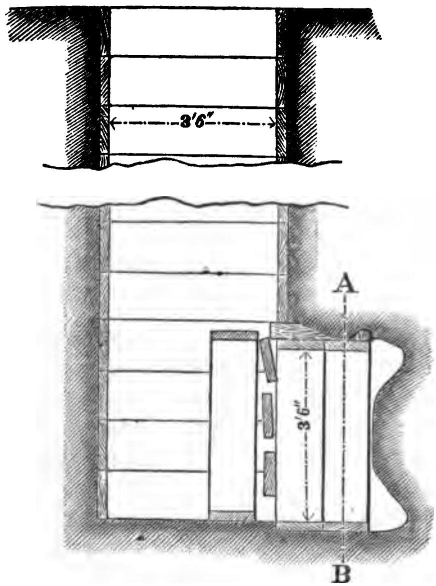


Fig. 24.—Commencing Gallery with Cases.

In this way the shaft is continued to the required depth. The ends of the five (or six for a common gallery) lowest are omitted where it is intended to break out the gallery, the sides of the shaft being there kept from closing in by end pieces of cases (Fig. 24), (which must not be allowed to slip into their usual places), or by means of battens.

In shafts in good soil that will stand without much support, the cases can be placed at intervals of 2 or 3 feet.

26. **Commencing a Gallery from the Bottom of a Shaft.**—The centre line of the gallery is marked as before.

Before the battens or ends are removed from between the sides of the shaft cases, a temporary case must be set up in the shaft, close to them, to take the thrust of the sides.

The first case of the gallery (Fig. 24) should be placed with its inner edge flush with the inside of the shaft, so that the sides of the shaft may have a bearing against it, and be prevented from collapsing, when the temporary case is removed. Just enough earth is excavated to allow the groundsill to be placed; grooves are next cut for the stanchions, and lastly a recess is made for the capsill, which is got in by fitting one end to the tenon of one of the stanchions, and cutting away sufficient earth behind the top of the opposite stanchion to allow the capsill to be placed on it; a sod or two must then be placed behind the last-named stanchion, to wedge it into its place. No more earth must be cut away behind the stanchions than is absolutely necessary (Fig. 25). The object of placing the various pieces of the case in grooves, and leaving the earth solid in the centre, is that it may be afterwards picked down to the groundsill, whence it is more easily removed than from the floor of the gallery before the groundsill is placed. The temporary case is now removed, and the last *complete* case of the shaft supported by wedges or pickets driven over the capsill of the first gallery case.

Section on A B, Fig. 24.

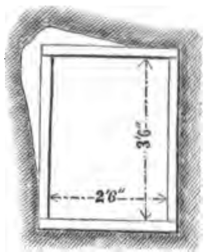


Fig. 25.—Recess Behind Gallery Case.

27. **Driving a Gallery.**—The succeeding cases are placed in a similar manner.

Close casing will seldom be required in a gallery, but the roofing should in most cases be supported; this can easily be effected by using pieces of the cases as top sheeting, resting on the capsills of the regular cases, with bearings of 2″.

28. **Changing Direction of a Gallery.**—In changing the direction of a gallery without varying the slope, the change must be made gradually, fitting the cases close together at one side, and at intervals on the other side. (Fig. 26.) If

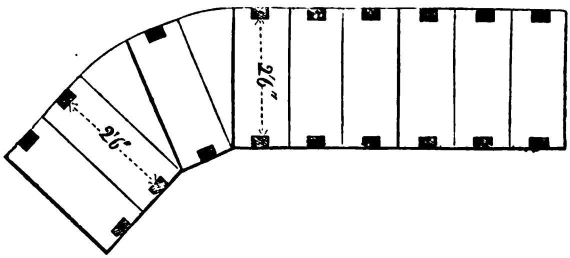


Fig. 26.—Changing Direction with Cases.

the soil be very bad, pieces of wood must be driven in between the cases in the openings, to support the earth.

29. **Breaking out one Gallery from Another.**—In breaking out one gallery from another, the requisite number of stanchions must be taken out to form the opening for the new gallery, and the capsills of these stanchions strutted up 2″ above their former level. The stanchions being removed, an excavation is made perpendicular to the old gallery, and the case is put up (2″ of the width of its groundsill having been previously sawed off) with its inner edge flush with the inside of the gallery, so that its capsill may support the capsills of the old gallery.

The temporary struts can now be removed, and the gallery proceeded with, any change of direction or diminution of size being made after the first case has been placed.

30. **Great Gallery Cases.**—Great gallery cases are somewhat different from other cases. To give them greater strength, the stanchions are made without tenons at their lower ends, which are kept in their places by cleats, 2″ thick and 7″

wide, nailed on to the groundsills (Fig. 27); these serve also as guides to prevent the axles of guns striking the stanchions.

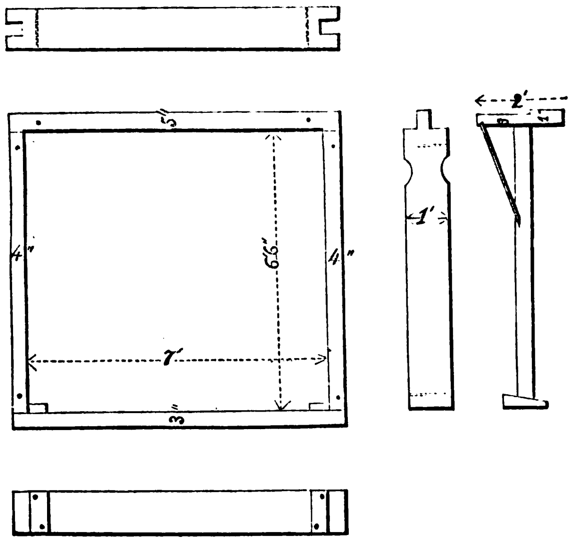


Fig. 27.—Great Gallery Cases.

The tenons at the tops of the stanchions are 2″ long, and fit into mortises which are cut only $2\frac{1}{4}$″ into the lower sides of the capsills. There are hand-holes on each side of the stanchions 1′ from the top.

31. **Driving a Great Gallery.**—The first case is got in by simply excavating the earth to a distance of 1′, setting up the case complete and pushing it into the excavation. In placing the next and following cases, two wooden crutches (each consisting of an upright piece of timber carrying a cross piece as shown in Fig. 27) are used, the shanks or feet of which rest on the groundsill of the case already placed, while the head of each crutch, being 2′ long, projects about a foot in front of the

cap of the last case. The crutches are set up, and an excavation made large enough to admit the cap of the next case, which is laid on the projecting ends of the crutches, and being supported by them, prevents the earth over the roof of the gallery from falling, while the excavation is continued to admit the remainder of the new case. The groundsill is first placed, and then the stanchions, one after the other, the earth in the centre being afterwards cut away and removed in wheelbarrows. The crutches are then removed and set up on the sill of this new case, previous to the placing of a fresh one (Fig. 28).

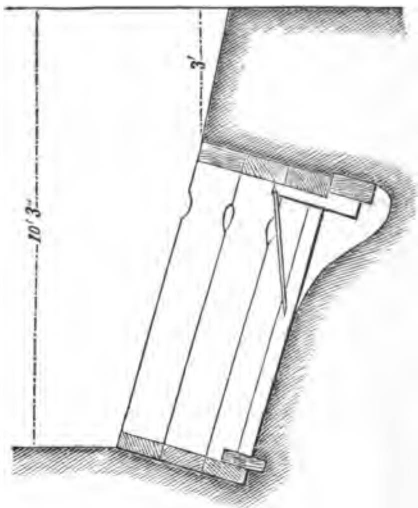


Fig. 28.—PLACING A GREAT GALLERY CASE.

The back of the head of the crutch (Fig. 28) is braced by an iron bolt and nut to the upright. The fore part of the head is 2″ higher than the back, in order that each new capsill in succession may stand at first somewhat higher than its final level, so as to clear the tenons of the stanchions. The crutch is steadied and tightened up by a wedge driven into a groove in a box called a shoe, placed under its foot.

32. **Commencing a Great Gallery.**—A great gallery is commenced by sinking a shaft 10′ square at the bottom and 10′ deep for the entrance, to allow of a minimum of 3′ of earth over the first capsill, a ramp being afterwards cut down into this excavation to communicate with the gallery.

VENTILATION OF MINES.

33. **Necessity of Ventilation.**—Great attention must be paid to ventilation in driving extensive galleries, as any gases contained in the soil or generated by the explosion of the powder, will collect in ascending and descending portions, and may prove fatal before the miner is aware of their presence. Even under ordinary circumstances, the air becomes so vitiated by the presence of the workmen, that galleries cannot be driven safely for more than 60′ without adopting some method of procuring artificial ventilation.

34. **Means Employed.**—The following are the means usually employed:

1. When two galleries are parallel to each other, communications cut at intervals between them produce a current of air.

2. A hole bored upwards to the surface answers the same purpose.

3. Air may be supplied from the miner's bellows, through short lengths of pipes fitting into each other, and prolonged as the excavation proceeds.

4. A very large supply of air may be provided by ventilating fans worked by two men, and having lengths of canvas hose connected with them.

35. **Ventilating Fan.**—Ventilating fans may be made of various patterns. Fig. 29 shows a simple one. The pipe for

conveying the air from *a* should be 6″ in diameter, and should be attached to the top of the gallery; the box in which the fans revolve may be made of wood or sheet iron; it has only two fans, formed by a single board *c c*; the axle to which it is

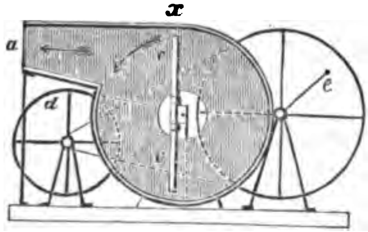
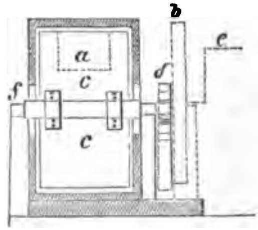


Fig. 29.—Ventilating Fan.



Section at x.

attached is turned by a strap, shown by dotted lines, passing round the tire of the wheel *b*, which is worked by the handle *e*.

LIGHTING OF MINES.

36. **Reflection of Light.**—Besides the ordinary means of procuring artificial light, lanterns and candles, galleries communicating with shafts may be lighted sufficiently for the purposes of the miner, for short distances, by using a bright tin plate as a reflector, placed at an angle of 45° at the bottom of the shaft, a second plate being used over the shaft to reflect the light downwards on to the plate at the bottom. This mode being available only while there is daylight, renders it desirable to load mines, if possible, during the day, and thereby avoid the danger of using lights.

TIME REQUIRED FOR MINING.

37. **Time with the Different Linings Compared.**—The time required for sinking a shaft or driving a gallery will be the same whether frames and sheeting or cases are employed.

38. **Time in Good Soil.**—It will vary between wide limits with the character of the soil, and the more or less skill of the workmen. In good soil, that is, soil which will stand well but yields readily to the pick, and with well-trained miners, the work may be expected to advance one yard for a

	hours.	min.
Great gallery in	4	0
Principal " "	3	0
Common " "	2	0
Branch " "	1	40

SECTION II.—PREPARING MINES FOR EXPLOSION.

DEPOSITING THE POWDER, ETC.—TAMPING.

DEPOSITING THE POWDER.

39. **Chamber.**—The position of the charge, as well as the quantity of powder to be used, having been determined, the chamber is cut at right angles to the branch.

40. **Depositing the Powder in Dry Soil.**—In dry soil the powder may be put in bags containing 40 or 50 lbs. each, some brushwood or straw being previously put into the chamber to prevent the outside of the bags being in immediate contact with the ground.

41. **In Damp Soil.**—In damp soil the outside of the bags must be covered with waterproof composition,* or greased, or tarred, or the powder put into a box, which is first placed in the chamber and filled afterwards. When the charge does not exceed 100 lbs. the ordinary powder barrel may be used to contain it. The size of a box to hold the powder may be calculated, recollecting that one pound of gunpowder measures 30 cubic inches.

42. **Introducing the Fuze.**—Before proceeding with the tamping, the charge must be connected with the surface by a fuze, etc. The fuze need only be connected with one bag, as the explosion of the first will instantaneously ignite the remainder. With very large charges, more than one fuze should be used.

TAMPING.

43. **Object of Tamping.**—The tamping of mines consists of filling up the gallery with solid material, for a certain distance from the chamber, with the view of preventing the force of the explosion expending itself in the gallery, rather than in the direction in which the mine is required to act.

44. **Amount Necessary.**—The tamping should extend from the charge for a distance equal to at least 1½ times the line of least resistance, and if the material used for forming the tamp-

* A waterproof composition may be made as follows: beeswax, tallow, and pitch in the proportion by weight of two parts beeswax, two parts tallow, and eight parts pitch, are melted together over a slow fire, but not allowed to boil, and stirred well together.

To coat the bags, first fill them with dry sand, then pay them over twice with the composition, letting the first coat cool before the second is laid on. When the second coat is cool, some finely-powdered chalk or whitening is shaken over the whole of the bags, to prevent the composition from sticking to anything, and thereby detaching itself from the canvas.

ing be not heavy, or but loosely packed, the distance should be twice that line.

45. **Materials Employed.**—The materials usually employed in tamping, consist of the earth which has been excavated in the formation of the gallery, of sods, of sand-bags, or indeed of any heavy substance which may be at hand. If the soil be clay, it may be roughly moulded into bricks, which form an excellent material, and one with which the operation proceeds quickly. Tamping with sand-bags is, however, the most expeditious method, and this material is the most easily removed after the explosion.

46. **Means of Strengthening Tamping.**—In tamping galleries, it is often desirable to strengthen the mass by pieces of timber crossing each other diagonally, and with their ends securely jammed into the sides of the gallery.

47. **Time Required in a Common Gallery.**—In a common gallery ($4\frac{1}{2}' \times 3'$) the tamping, when made of common earth and well rammed, will advance at the rate of about 2 to 3 feet per hour.

48. **With Increased Charge Tamping may be Diminished.**—In proportion as the charge is increased, the value of the tamping diminishes. When the tamping is diminished one-third, the charge should be increased one-fourth; when the tamping is diminished by two-thirds, the charge should be increased one-half; and when the mine is not tamped, the charge should be doubled.

SECTION III.—FIRING MINES.

POWDER HOSE AND FUZES.—ELECTRICITY.

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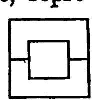
49. **Means Employed for Springing Mines.**—Mines may be fired, or as it is technically termed sprung, by a powder hose, by the ordinary safety fuze, or by electricity.

POWDER HOSE AND FUZES.

50. **To make Powder Hose.**—Powder hose is made of strips of strong linen; the edges are turned over outwards, and the double parts brought together and serged, by passing the needle alternately through the four thicknesses of stuff, and back over all. For one-inch hose, strips 4″ wide are used, and the turnovers are each half an inch wide.

51. **Filling Powder Hose.**—Powder hose is filled by means of copper funnels; a hose of about 20′ in length may be filled from the upper window of a house, or any convenient height; when longer, it must be filled in sections and sewn together.

52. **Laying Powder Hose.**—It is laid along an angle of the gallery or shaft, and is protected by straw rope wound round it, or by enclosing it in a hollow wooden case, represented in cross section as follows, the exterior dimensions of the case being 3″, and the interior $1\frac{1}{2}''$. The case is made of $1\frac{1}{2}''$ plank, and is secured by wooden pegs. In galleries and branches, after it has been secured, it is usually covered with earth, to prevent accidents during the operation of tamping.



53. **Rate of Burning of Powder Hose.**—Powder hose burns at the rate of from 10 to 20 feet per second.

54. **Firing the Powder Hose.**—The mine is fired by a piece of port-fire inserted into the end of the powder hose, of such length as will give time to the man who fires it to escape before the explosion takes place. The port-fire is then covered all round with moist clay, well kneaded with the hands, and earth arranged so as to render it impossible for any fire to communicate with the powder hose till the port-fire shall have burnt out.

If the hose is to be fired with the safety fuze, the latter is merely pushed into it and tied tightly in, the hose and joint being covered up as before.

55. **Making Straw Rope.**—Straw rope is made by two men; one commences a small piece of rope by hand, and fixing it to the end of a hooked stick, walks backward turning the handle, while the other man adds straw as required.

56. **Simultaneous Explosion of Several Mines.**—When it is desired to spring several mines simultaneously from one point, it is necessary that equal lengths of powder hose should extend from the point of ignition to all the mines. To effect

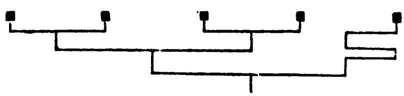


Fig. 30.—EQUALIZING LENGTH OF POWDER HOSE.

this, the hose of the mines nearer to the point of ignition must be bent more frequently than those leading to the more distant ones (Fig. 30). The bendings of the hose will not practically affect the rate of burning.

57. **Slow Match.**—Rope steeped in a solution of saltpetre and lime water makes good slow match, and burns at the rate of 1′ per hour; before being used the ash must be blown off.

58. **Port-fire.**—Port-fire burns at the rate of 1″ per minute.

59. **Mealed Powder.**—Common mealed powder, moistened and pressed firmly into a tube, burns at the rate of 2′ per minute, and may be used as a fuze when no other is procurable.

60. **Safety Fuze.**—The ordinary safety fuze burns at the rate of about 3′ per minute.

ELECTRICITY.

61. **Electricity.**—Mines should always be sprung by electricity when possible. The wires must be perfectly insulated, and should be thoroughly tested by the explosion of cartridges on the exterior, before they are laid in the mine.

62. **Laying the Wires.**—Great care must be taken that they are not injured in the operation of tamping. They are laid in a wooden trough $1\frac{1}{2}''$ square in the clear in cross section, having a flat cover. After the wires are laid this trough is filled with dry sand and the lid is nailed down, care being taken to drive the nails outward. The trough is then covered with a few inches of earth.

63. **Electric Machines.**—The most convenient machines for producing the electric current for military purposes are the friction machine of Mr. H. Julius Smith, and Beardslee's magneto-electric machine. Each has exploders particularly adapted to it. Each has some defects, as is the case with all machines yet invented. The first is the best for the explosion of a large number of charges. Care must be taken that the exploders are not too sensitive, to avoid accidents from atmospheric electricity.

SECTION IV.—CHARGES AND NOMENCLATURE OF MINES.

CRATERS, ETC.—RULES FOR CALCULATING CHARGES—EXPLOSIVES.

CRATERS, &c.

64. **Radii of Rupture.**—When charges of powder are fired under the surface of the ground, the effects caused by their explosion necessarily depend on the quantity of powder used, on the depth below the surface at which it is placed, and on the nature of the soil. Besides the effect of disturbing the earth on the surface of the ground, an internal commotion is produced, capable of destroying any shafts or galleries in the immediate neighborhood. The distances from the charge to which this commotion extends are called the radii of rupture.

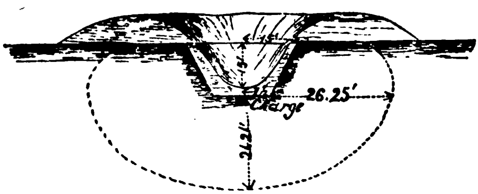


Fig. 31.—Section of a Common Mine.

When the charge is so small as not to produce any effect at the surface, the radii of rupture may be expected to be equal in all directions, if the soil be homogeneous. But when the charge is sufficiently large to produce a crater, it is generally found that the horizontal radii of rupture are much greater than the vertical radii (Fig. 31).

65. **Definitions.**—The radius of the circular opening on the ground is called the radius of the crater. The shortest line drawn from the centre of the charge to the surface of the ground is called the line of least resistance (L. L. R.) and is *always measured in feet.* The line drawn from the centre of the charge to the edge of the crater is called the radius of explosion.

A crater of which the diameter is equal to the line of least resistance, is called a one-lined crater; when the diameter is double the line of least resistance, a two-lined crater, and so on.

Mines charged so as to produce two-lined craters are known as common mines; if more heavily charged, they are called globes of compression or overcharged mines; those with smaller charges, undercharged mines; and those with charges so small as not to produce any crater, camouflets. A small mine, with a line of least resistance not greater than 9′, formed by sinking a shaft from the surface of the ground, and placing the charge at the bottom of it, is termed a fougasse.*

Charges are said to be at one, two, three, &c., lined intervals, when the distances between their centres are respectively $\frac{1}{2}$, $\frac{2}{2}$, $\frac{3}{2}$, &c., of the sum of their L L R.

66. **Volume of Craters.**—The forms of craters being very irregular, from the fact that much of the earth falls back into them, there is some difficulty in selecting a regular figure whose solid content will be nearly equal to that of the crater. It is, however, allowed, that the content of a two-lined crater is equal to that of a truncated frustrum of a cone, of which the height, and radius of the larger circle, are each equal to the line of least resistance, and the radius of the smaller circle equal to half that line. The solid content of such a figure is equal to $\frac{11}{6}$ L L R^3.

* A species of obstruction called a stone fougasse, is often classified under the head of mining. It will be described under the head of obstructions.

RULES FOR CALCULATING CHARGES.

67. **Formulæ for Charges and Radii of Rupture in Earth.**—The following are the formulæ employed for calculating the powder charges of mines, and their radii of rupture in earth. Let $r =$ radius of the crater, and $c =$ charge of powder in lbs.

In a common mine $c = \frac{1}{10}\,\text{L L R}^3$.
In an overcharged mine $c = \frac{1}{10}\,[(r - \text{L L R})\,0.8 + \text{L L R}]^3$.
In an undercharged mine $c = \frac{1}{10}\,[\text{L L R} - (\text{L L R} - r)\,0.8]^3$.

An undercharged mine becomes a camouflet, when the value given to r in the equation is less than $\frac{3}{8}$ L L R.

The horizontal radii of rupture are

In a common mine $\frac{7}{4}$ L L R.
In an overcharged mine $\frac{7}{4}\,[(r - \text{L L R})\,0.8 + \text{L L R}]$.

The vertical radii of rupture are

In a common mine $\text{L L R}\sqrt{2}$ or $\text{L L R} \times 1.4142$.
In an overcharged mine $[(r - \text{L L R})\,0.8 + \text{L L R}]\sqrt{2}$.

68. **Charges for Different Media.**—The quantity of powder for a common mine in earth having been found by the above formula, the proper amount for a different medium may be obtained with sufficient approximation by multiplying the calculated amount by

1.25 for dry sand.
1.31 " wet sand.
1.41 " earth mingled with small stones.
1.55 " clay mingled with tufa.
1.66 " poor masonry.
2.25 " rock.
2.50 " good masonry.

EXPLOSIVES.

69. Gunpowder is the best explosive that can be used for mines. Gun-cotton, and nitro-glycerine in its many forms, as

nitro-glycerine proper, dynamite, dualine, lithofracteur, &c., may be used to advantage in hasty demolitions, but they are not suitable for mines in earth.

SECTION V.—ATTACK AND DEFENCE OF MINES.

70. **To Discover the Enemy's Miner.**—To discover the enemy's miner, any of the following means may be employed: Pierce a hole with a borer in the supposed direction of the enemy, and then apply the ear to the hole; place a drum on the floor of the gallery, and lay some peas or other light body upon its head tightly stretched; set basins full of water on the ground, and observe whether the surface of the water is perturbed.

71. **Means to Conceal Progress.**—To conceal his own progress from the enemy, the miner dispenses with the pick, when the soil is favorable, and detaches the earth with the push-pick or with a broad flat chisel, which is driven with the palm of the hand. Even with these precautions miners can be heard at a distance of 20′.

72. **Converting a Gallery into a Trench.**—A gallery, of which the floor is at a depth H feet below the surface of the ground, may be converted into a trench, by establishing masks of sand-bags at its two ends, and placing heaps of powder containing H 25 lbs. from distance to distance. These heaps should be about 13 yards apart and connected by powder hose. The trench produced by their explosion is about 7′ deep, with a parapet on each side.

73. **Powder to be Freely Used by Besieger.**—In subterranean warfare, the besieger must freely use powder and overcharge his mines, for by so doing he poisons the enemy's galleries, if he does not crush them in, and he forms broad craters which, crowned with a gabionade, will furnish him a lodgement. He can also forestall the besieged by suppressing the tamping, which the latter cannot do.

74. **Besieged to Use Powder Moderately.**—The besieged, on the contrary, must avoid excavating craters for his enemy, and must limit himself to the charges strictly necessary to destroy his branches and shafts, or to overthrow his saps, cavaliers, and breaching batteries.

SECTION VI.—DEMOLITIONS.

REVETMENTS.—POWDER MAGAZINES, ETC.—HOUSES.—BRIDGES.—STOCKADES, BARRIERS, ETC.

REVETMENTS.

75. **Position of Charges.**—The most effectual method of demolishing revetments without counterforts, is to place charges in rear of the general line of masonry; where counterforts exist, a charge should be placed in every counterfort or every second counterfort according to circumstances. The charges should be determined so that the craters shall not merely touch, but overlap each other. They should be placed in rear or in the body of the counterfort, and not further to the

Fig. 32.

front than the centre, as otherwise the revetment is liable to be torn from the counterfort, and the latter, though shattered, may be left standing. They should be placed about 3′ above the bottom of the ditch.

76. **Depth below Surface.**—It has been observed, in the demolition of revetments by mines placed behind them, that if there is a depth of earth above the charge equal to the line of least resistance on the side of the ditch, the demolition rarely failed, although the specific gravity and tenacity of the masonry and the earth differed so materially.

77. **Angles the most Favorable Position.**—Mines lodged in obtuse angles produce a greater demolition than when placed behind a straight revetment, and mines lodged in acute angles produce greater demolition than when placed in obtuse angles.

POWDER MAGAZINES, &c.

78. **Position of Charges.**—In buildings having very thick walls, such as powder magazines, casemates, &c., small galleries may be cut into the centre of the wall, and chambers formed in a recess on one side in the usual manner. If the masonry should be much harder than the soil upon which it is founded, it may be more convenient to sink shafts on the outside, and from thence to drive small branches until the centre of the foundation is reached.

79. **Charges to be Increased when Wall is Heavily Loaded.**—When the demolition of walls carrying a heavy arch or mass of masonry is to be effected, the calculated charges may be increased one-fourth with advantage.

80. **Tamping in Masonry.**—In tamping galleries cut in masonry, it is advisable to use strong spars of wood let into the sides. A tamping of common earth, nearly double the line of

least resistance of the masonry, will suffice for the strongest wall. If the branches cannot conveniently be extended far enough to obtain so much tamping, more powder must be used.

HOUSES.

81. **Position of Charges when Earth can be Procured Outside.**—In buildings having walls of moderate thickness it is difficult to make branches, because a man requires 2′ to work in. In such cases, if there be earth at hand, a series of charges should be laid along the outside of the wall. (Fig. 33.) A trench may be dug 8 or 10 feet from the wall, and earth thrown up over the charges as tamping. The depth of the earth ought to be at least $1\frac{1}{2}$ times the thickness of the wall. If the charges be sunk a little way

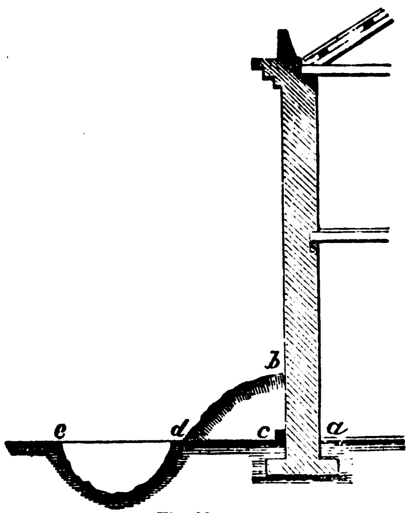


Fig. 33.

into the wall, say about one-third of its thickness, so much the better, as this will lessen the line of least resistance, and thereby diminish the quantity of trench work required for tamping.

The best position for such mines would be inside the building, but generally the space is too limited to obtain a sufficient quantity of earth there, even if wooden floors, &c., opposed no obstacle.

82. **Charges when Tamping cannot be had.**—Area walls, pavements, &c., may sometimes render it difficult to obtain earth for the tamping outside. In that case the charges must be greatly increased. Nitro-glycerine, &c., will be better than gunpowder, as requiring less tamping.

83. **Another Method.**—Another method is to place several kegs of powder with connecting trains along the weakest portion of the walls, to buttress the roof or upper floor against heavy timbers laid over the kegs, and fire after barricading the doors and windows.

84. **Method to Economize Powder.**—If time permits and economy of powder is an object, the lower part of the walls may be cut away, leaving piers about 10′ apart sufficient to support the upper part. The piers are then blown up.

85. **Method when no Explosive is at Hand.**—If no explosive is at hand, and the walls are not thick, the lower part may be cut away, the upper part being left supported by pieces of wood, which are afterwards set on fire.

86. **General Rules to be Observed when Time Presses.**—When time presses it is in general to be remembered that most execution will be done at angles and the junction of walls, that nitro-glycerine or one of its compounds is the best explosive material, that gunpowder, unless confined, must be used by the barrel, and that it is better to have a charge too large than too small.

87. **To Destroy a 14-inch Wall.**—A 14-inch wall, however well built, can be breached by charges of 60 lbs. of powder, weighted with sand-bags, the charges being not more than 5 or 6 feet apart.

BRIDGES.

88. **Masonry Bridge with High Piers.**—In a bridge with high piers, mines should be made in the bases of the piers, as the fall of one pier will bring down two arches. The best plan is to attack the piers near their bases, with a series of charges at two-lined intervals, exploding them all simultaneously. (Fig. 34.)

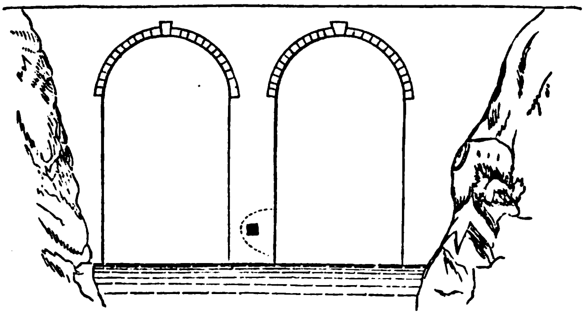
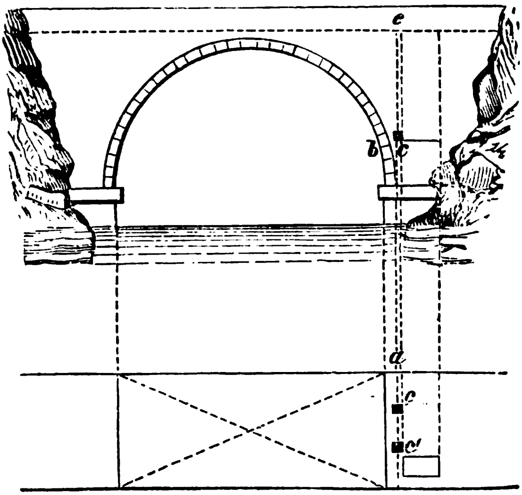


Fig. 34.

89. **Masonry Bridge with Short, Thick Piers.**—When the piers are short and thick, it is better to attack the arches than the piers. The arch of a bridge, owing to its form, offers a greater resistance to the explosion of a charge, than a flat wall of the same thickness would. Hence if a charge were placed at the same distance from the arch that it is from the side wall, the latter would offer the least resistance, and might be destroyed while the arch was left standing. In Figures 35 and 36, *c a* should be equal to twice *c b*, and *c e* not less than 3 *c b*. If the arch is to be destroyed with a single charge, *c b* should be equal to one-fourth the breadth of the bridge. Unless the bridge is very narrow, however, it is better to place two or more smaller charges across the haunch of the arch, than to place a single large one in the centre.

When two or more charges are arranged across the arch, they

should not be distant from each other more than 2 L L R. The L L R should be regulated by the thickness of the vous-



Figs. 35 and 36.

soirs, and should not, as a general rule, be less than 1½ feet, or more than 5 feet.

90. **Same when Time Presses.**—When time will not

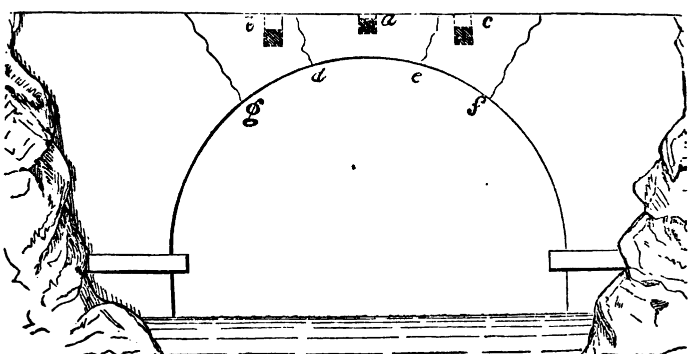


Fig. 37.

admit of an attack on the haunches of piers, operations must be confined to those portions where there is the least covering over the arch, viz.: the vicinity of the key-stone. Over the key-stone itself, as at *a* (Fig. 37) the arch could be reached with the least amount of excavation, but a greater breach could be formed by firing charges at *b* and *c*.

91. **Same in Case of a Thin Arch.**—Another mode of hasty demolition, when the arch is a thin one, is to suspend the charge below the crown of the arch, in a trough. By this arrangement the arch would be attacked at its weakest point, and in a favorable direction, and there would be no interruption to traffic.

92. **Wooden Bridges.**—The most obvious method of destroying wooden bridges is by setting them on fire. In certain cases, it may be desirable to have the effect more instantaneous. This may be effected by boring 2″ auger holes in the timbers, and exploding nitro-glycerine or gun-cotton in them.

93. **Iron Girder Bridges.**—When a bridge is formed of large iron girders supported on masonry piers, the simplest mode of demolition is to destroy the piers. Wrought-iron girders may be destroyed by means of large fires of sleepers, etc., lighted against them. If made red hot, they will sink from their own weight.

94. **Suspension Bridges.**—Suspension bridges can be destroyed by uncovering and loosening one anchorage, or by blowing up one of the supporting piers of the cable, at a point some distance below the saddle.

STOCKADES, BARRIERS, ETC.

95. **Stockades and Palisades.**—In blowing down a stockade or barrier, the powder is placed in a tarred sand-bag or two, or a leather bag made for the purpose. The effect of the

explosion will be much increased if the bag containing the powder be surrounded with five filled sand-bags. (Fig. 38.) The powder bag being laid on the ground with the fuze outwards, a sand-bag is placed on the top, one at each side, and two in front, so as to allow the fuze to project between them. A charge of 40 lbs., covered with sand-bags, or 60 lbs. uncovered, will make a breach 6′ wide through a stockade formed of timbers 10″ thick.

Fig. 38.

The same method may be used in destroying palisades.

96. **Barriers or Gates.**—Against a gate or barrier, the best place for the charge is opposite the lock, bolts, or hinges, where it should be either secured by a prop, or suspended from a nail or gimlet. In the case of a town gate, or other very strong gate, 200 lbs. of powder would be required.

PART II.

PRACTICAL OPERATIONS OF A SIEGE.

PART II.—PRACTICAL OPERATIONS OF A SIEGE.

Section VII.—TIMBER, ETC.

Timber.

Brushwood.

Section VIII.—FABRICATION OF TRENCH MATERIAL.

Fascines.

Gabions.

Sap-rollers.

Hurdles.

Pickets.

Sand-bags.

Section IX.—PARALLELS AND APPROACHES.

General Description.

Detail of Working Parties.

Tracing.

Extending Working Parties.

Execution by Simple Trench.

Trench Railways.

SECTION VII.—TIMBER, &c.

TIMBER.—BRUSHWOOD.

TIMBER.

97. **Timber, Uses to which Applied.**—Timber is an article of first necessity to the military engineer, being used in the construction of huts, temporary bomb-proofs, splinter-proofs, powder magazines, gun and mortar platforms, mining frames, stockades, palisades, chevaux-de-frise, abatis, barriers; also for building bridges, and for numberless other engineering purposes in connection with an army in the field.

98. **How Procured.**—When possible it is procured by purchase or by the destruction of buildings of size and form adapted, or capable of being easily adapted, to the purposes for which it is required; but frequently it has to be obtained by felling trees, which for facility of transportation should be squared and cut, where felled, into timber of appropriate dimensions.

99. **Felling and Preparing Timber.**—Timber is usually felled with the axe; the tree should be first nicked on the side on which it is required to fall, a rope being used, if necessary, to pull it over. An experienced axeman can square timber, and cut it into various rough shapes fitted for most of the above purposes, without any other tool than the axe; but when the timber has to be prepared by the artificers attached to the army, it becomes necessary to provide them with the tools that they have been accustomed to use.

100. **Rate of Felling Timber.**—Soft wood trees 2′ in diameter can be felled by four inexperienced men in from 15 to 30 minutes, and trees 1′ in diameter in about half that time; they can be cross-cut into three lengths in from 20 to 30 minutes more. Care should be taken to select for cutting timber soldiers who have been accustomed to the use of cutting tools; otherwise the number of tools destroyed will be great, and the amount of work done will be small.

101. **Tools for Felling Timber.**—The following are the tools likely to be required by a party of 100 men in felling and removing timber:

Axes, felling	60	Cant-hooks, iron	10
Bill-hooks	12	Hand-saws, 26 inch	12
Handspikes, 6′	16	Grindstones	4
Chains, $1\frac{1}{4}''$, 5 fathoms, with hooks at ends	4	Measuring tapes (50′)	2

102. **Tools for Preparing Timber.**—The following are the tools likely to be required by a party of 100 men in preparing timber:

Broad axes, carpenters	40	Measuring tapes, 50′	4
Adzes, carpenters	16	Files, Saw: Cross-cut, 7 inch	20
Saws: Cross-cut, 5 feet	8	Files, Saw: Pit, 5 inch	20
Saws: Pit, 7 feet	8	Files, Saw: Hand, 5 inch	40
Saws: Hand, 26 inch	24	Sets, Saw: Cross-cut	4
Sledge hammers	4	Sets, Saw: Pit	4
Grease, lbs	50	Sets, Saw: Hand	8
Chisels, socket, 2 inch	16	Pick-axes, for saw-pit	8
Mallets, carpenters	8	Shovels, for saw-pit	8
Squares, iron, 24 inch	8	Chalk-lines	8
Stones, Grind, 10 inch	4	Wedges, iron, 6 inch	12
Stones, Rub, 12 inch	2	Rules, carpenters, 2 feet	8
Stones, Rag or whet	2	Measuring rods, 6 feet	8

BRUSHWOOD.

103. **Brushwood, Uses to which Applied.**—Brushwood is used for making gabions, fascines, sap-rollers, hurdles, for watling, &c., and is best cut when the leaf is off. Hickory, birch, ash, hazel, and willow are most fitted for use. The rods should not exceed 2″ in diameter at the butt end for fascines, and ¾″ for gabions.

104. **Tools for Cutting Brushwood.**—The best tool for cutting brushwood is the hand-hatchet. Bill-hooks are sometimes used, in which case the cut should always be made upwards if possible.

105. **Working Parties for Cutting Brushwood.**—Men for cutting brushwood are divided into parties of 25. Each party can cut half an acre in from five to nine hours; or each man can cut an area of 24 yards by 4 yards, or 96 square yards. It will be found convenient, therefore, to form each party in single rank, with intervals of four yards between the men; and to give them as a task to clear a space 24 yards to their front. Parties may be set to work in parallel lines, provided an interval of 24 yards be left between them. Each man binds up what he cuts in bundles weighing from 40 to 56 lbs. each, the bundles being loosely bound with withes.

SECTION VIII.—FABRICATION OF TRENCH MATERIAL.

FASCINES—GABIONS—SAP-ROLLERS—HURDLES—PICKETS—SAND-BAGS.

FASCINES.

106. **Fascines Described.**—A fascine is a bundle of rods closely bound up. When the term is used without further specification it implies a Battery Fascine, or one about 18′ long and 9″ in diameter, such as is used in revetting batteries, &c. Trench Fascines, 6′ long, are used for crowning a line of gabions in a sap. They are made by merely sawing the common long fascine into three parts. In like manner 9′ fascines, which are useful for covering blinded galleries and for other purposes, are formed by sawing the common long fascine into two equal parts.

107. **Weight.**—The average weight of a battery fascine, when the wood has been cut some weeks, is 140 lbs.

108. **Fascine Trestle.**—Fascines are made in a cradle composed of 5 pairs of trestles. Each trestle consists of a couple of stakes about 6′ 6″ long and 3″ in diameter, driven obliquely into the ground, touching each other, and crossing at right angles or nearly so. The upper angle of the cross should be 2′ 6″ from the ground, with the ends of the stakes projecting obliquely about 2′ beyond it, as shown in Fig. 39. At the centre of the cross, the stakes are bound together by a

lashing 6′ long, of spun-yarn or tarred line. If this cannot be procured, a withe or twisted rod will answer the purpose. The middle of the lashing or withe is applied to the two stakes and the ends are passed horizontally round both until three or four turns are taken. The ends are then crossed vertically in the space between the two stakes and hauled taut. Two or three turns are taken in this new direction (Fig. 40) and the ends are then tied together.

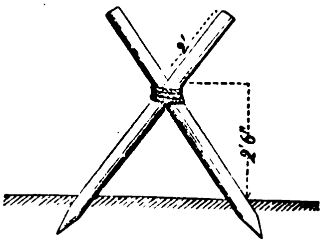


Fig. 39.—Fascine Trestle.

The two end trestles are first placed 16′ apart, and a cord stretched between their upper angles. The remaining three are then inserted at intervals of 4′, great care being taken that all the trestles touch the cord similarly; otherwise the fascines will be irregular in form.


Fig. 40.

109. **Construction of Fascines.**—When the trestles are fixed, straight rods of brushwood from 1 to 2 inches in diameter at the butt are laid over them, projecting about 1′ beyond the extreme trestles. The leaves must be stripped off, as also any small branches which grow out of the stems with clumsy bendings. Straight and flexible branches may be laid in along with the stem, cutting them half through or not, as may be necessary. The stouter rods must be laid on the outside with the thick ends alternately in different directions, and the smaller stuff near the centre. When the cradle is nearly full, the diameter of the fascine is proved with the fascine-choker, and more stuff added to those parts which require it.

110. **Preparation of Withes.**—Fascines are bound with withes, or with spun yarn, or wire. The best rods for withes

are hickory or hazel; they should be 5′ long, not less than $\frac{3}{8}$ inch in diameter, nor greater than $\frac{3}{4}$ or $\frac{7}{8}$ inches at the large end; all the small branches must be trimmed off, leaving a small stump one-eighth of an inch long for each. In making a withe, the thick end of the rod is placed under the left foot, and the rod twisted with the hands from the top downwards, taking care to avoid kinks. When the rod is well twisted at the small end, and moderately so downwards, a loop about 9″ long is made at the small end, by taking a half hitch with the end of the rod round the body or standing part of it. (Fig. 41.) The loop is then given a couple of twists in the contrary direction, so as to plait the double part of the rod and form an eye or smaller loop at the top of it. (Fig. 42.) The other end is then pointed and the withe is complete.

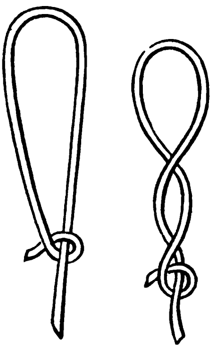


Fig. 41. Fig. 42.
PREPARATION OF WITHES.

111. **Choking Fascines.**—The fascine-choker consists of two wooden levers of 2″ by $1\frac{3}{4}$″ stuff, 4′ long, with the edges rounded, having a chain 4′ long secured by iron sockets at a distance of 1′ 6″ from the ends (Fig. 43). Two small rings are fixed on the chain $28\frac{3}{4}$″ from each other and equidistant from the centre, as a gauge for the circumference of a fascine. It might be desirable to make fascines of a different diameter from the ordinary, in which case the length of the chain of the choker should be different. Five and a half times the diameter is a good proportion. If proper chokers are not to be had, a couple of stout stakes and a rope doubled by splicing or by tying the ends together will answer the same purpose.

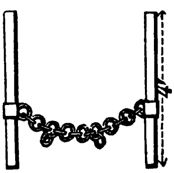


Fig. 43.—FASCINE CHOKER.

Two men standing one on each side choke the fascine by

placing the centre of the chain under the brushwood on the trestle, the short ends of the levers being upwards, handing the levers to each other over the fascine with the short ends down, and then bearing down on the long ends of the levers till the gauge rings meet. Fig. 44 shows the positions of the levers

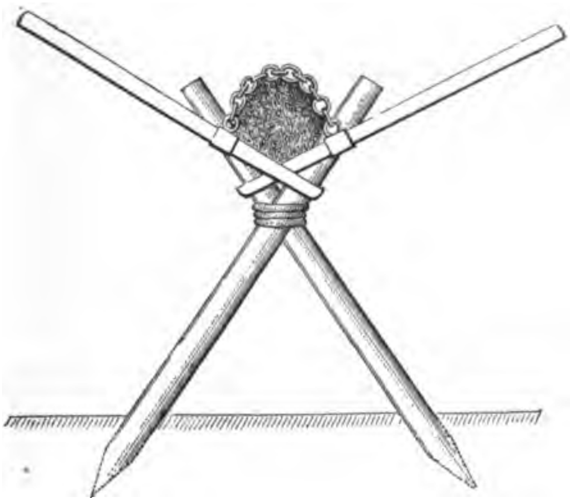


Fig. 44.—Choking a Fascine.

and chain during the operation. The chain is supposed to have made rather more than one complete turn round the fascine.

112. **Binding Fascines.**—Binding is done by two men, who stand one on each side of the fascine, and bind it close to the choker. The first withe is put on at one end, about 3″ beyond the trestle. It is passed under the brushwood and the ends brought up; the point is then passed through the eye and hauled taut by one man who twists the withe as he does so. He then hands it over to the other man, who bends it back, so

as to form a new loop engaged within the former like two links of a chain, after which he passes the end of the rod from left to right, under the standing part on his own side, over it again, and then under it a second time; whilst the first man assists with the fid in disengaging the standing part, which at this time is, of course, jammed close to the body of the fascine. After the second turn, the superfluous part of the rod is cut off. (Fig. 45.) The remaining eleven withes are now put on at intervals of about 18″, and the ends of the fascines are then sawed off about 9″ outside the extreme withes, making it 18′ long. (Fig. 46.) When yarn is used, it is passed twice round the fascine, hauled taut, and fastened with a reef knot. Wire is sometimes used for binding; it is passed twice round, and the ends are twisted well together, and then pushed under some convenient rod of the fascine.

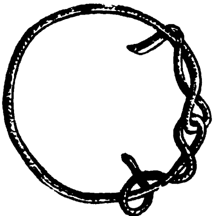


Fig. 45.—Binding a Fascine.

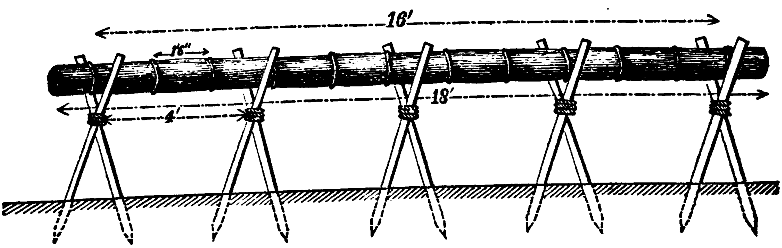


Fig. 46.—Fascine Complete.

The advantage of using 12 withes is, that the fascine can be cut up, without interfering with them, into 9′ or 6′ lengths, thus having a withe 9″ from each end; more withes must be used when the brushwood is very small.

113. **Men, Time, and Tools for making Fascines.**—A squad of five men will, after a little practice, make a fascine in

an hour; two select the wood and choke, two place the wood on the trestles and bind, while the fifth prepares the withes. Four men are sufficient if the fascine be bound with wire or yarn. The tools required for each squad are 1 fascine choker, 1 eighteen inch gauge for the distance between bands, 3 bill-hooks or hand hatchets, 2 gabion knives, 1 piece cord 20′ long, 1 wooden mallet, 1 six feet measuring rod, 1 handsaw. For every five squads will be required 1 grindstone, 1 rub-stone, and 1 whetstone. There will be one non-commissioned officer to every five squads.

114. **Fascine Pickets.**—When the fascines are to be used in a revetment seven pickets will be required for each fascine. They are made up in bundles containing 25, tied together with a withe or piece of spun yarn. They should not be less than 3′ 6″ long, including the points, but 4′ is better. A sharp triangular point is the best way of finishing the picket. The top should also be pointed, but very obtusely as in Fig. 47. Fascine pickets are from $1\frac{1}{4}$ to $1\frac{3}{4}$ inches in diameter at the thick end. A bundle weighs about 30 lbs., and can be made by one man in an hour.

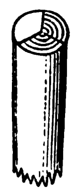


Fig. 47.

115. **Sap Fagots.**—A sap fagot is a short but very strong fascine, about 3′ long and 9″ in diameter, made of stout picket stuff. It is used for filling the interstices between the gabions at the head of a sap when sand-bags are not procurable. One picket projects 5 or 6 inches from the end of the sap fagot, and is driven into the ground to keep it steady. Sap fagots are sometimes used for filling the gabions themselves, to hasten the progress of a sap under peculiar circumstances. Two men can make one in 20 minutes.

GABIONS.

116. **Gabions.**—Gabions are cylindrical baskets, open at both ends, which being filled with earth are musket proof and form a revetment useful in field works. In our service they are usually made of brushwood or hoop iron, and are generally 2′ in exterior diameter and 2′ 9″ high in the web, but averaging 3′ in height when used as a revetment, in consequence of the projecting ends of the upright rods or pickets. In wicker gabions the interlacing of the brushwood is called the watling or web.

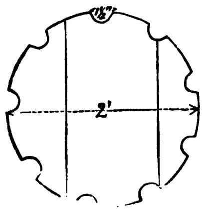


Fig. 48.—Gabion Form.

117. **Gabion Form.**—A gabion form is a circular piece of plank 21″ in diameter, with 9 equidistant notches cut in its edge. (Fig. 48.) These notches are semicircular and have a radius of $\frac{3}{4}$″.

118. **Gabion Pickets.**—The pickets are 3′ 6″ long and about 1″ in diameter; they are pointed at one end.

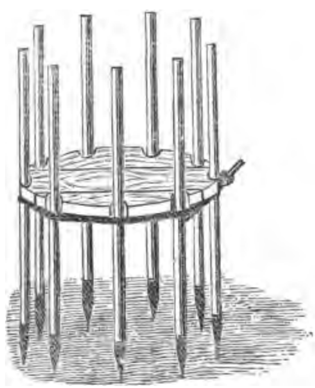


Fig. 49.—Gabion Form in 2nd Position.

119. **Preparations for Watling.**—The form is laid upon a level spot, and the pickets are driven into the ground through the notches, their thick and thin ends alternately downwards. The form is then raised one foot from the ground, and the pickets are bound firmly into the notches by means of a rope and rack-stick, the rope passing round the pickets just below the form. (Fig. 49.)

120. **Watling.**—The rods for the web should be from $\frac{3}{8}$ to $\frac{3}{4}$ of an inch in diameter. They should be entirely stripped of

leaves and twigs, no part of any one single rod being used double, although in joining a new rod to the tip of one that is coming to an end these two may be laid together for a few inches. That part of the gabion above the form is made first. The web is commenced by placing two rods with their butts inside two adjacent pickets. (Fig. 50.) The one which is to the rear is passed over the other rod, round one picket, and within the next. The second rod, which is now to the rear, is passed over the first rod and also outside one picket and within the next. Thus the two rods cross each other over and under, as in Fig. 51. When a rod is coming to an end the butt of a fresh one is laid overlapping the tip of the old one by a few inches, and the two are worked together as a single rod. The process is continued to within 3″ of the tops of the pickets. Particular attention must be paid to the uniformity and closeness of the web; it should be pressed down by frequent taps of a mallet or picket.

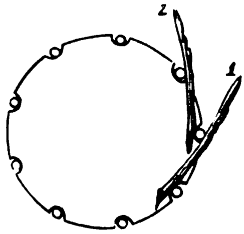


Fig. 50.

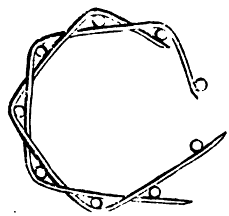


Fig. 51.

121. **Sewing of Wicker Gabions.**—When the web is completed to the proper height it is sewn down in four places with withes. Some of these are applied so as to secure the ends of the last rods. The centre of the withe being laid over the top of the web, the ends are passed through it in contrary directions a few inches from the top, near to each other but not between the same two rods. Two men haul upon them until they are quite taut. They then pass them again through the web a few inches lower down, in contrary directions, and haul taut a second time; and thus they proceed by shoemakers'

stitches until the ends of the withe arrive at the form. The ends must be neatly secured. The tops of all the pickets must be cut off about an inch above the web.

122. **Finishing Wicker Gabions.**—The form is then removed, the gabion turned over, and the watling proceeded with as before. When the total height of watling is 2′ 9″ it is sewn down with four withes as before. The points of the pickets which originally stood in the ground are left projecting from the end of the gabion. (Fig. 52.) The small ends of the rods are trimmed off; and lastly a carrying picket is driven through the sides of the gabion about the centre of its height and 9″ from one side.

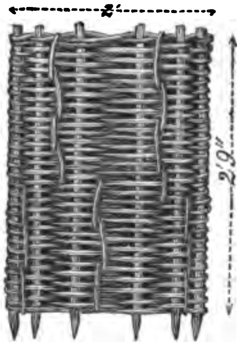


Fig. 52.—GABION COMPLETE.

123. **Construction of Wicker Gabions without Forms.**—If gabion forms cannot be obtained a circle of 10½ inches radius is traced on the ground. The circumference is divided into as many equal parts as there are pickets, the number being usually 9, but if the brushwood be very small 12 or 14 may be used. The pickets are driven into the ground, touching the circumference at the points marked. The watling is commenced at the ground and carried up to the total height of 2′ 9″, when it is sewn down at both ends as before. The diameter must be frequently gauged, and the proper distance between the pickets maintained throughout.

124. **Time required to make a Wicker Gabion.**—Without the gabion form three men can make a wicker gabion in about two hours, one man preparing the rods and withes, one man watling, and the third man holding the pickets. With the form two men can make one in about an hour and a half.

125. **Tools, &c.**—The tools for each party are 1 gabion form, 1 rack lashing 5′ long, 1 hand hatchet, 1 handsaw, 2 gabion knives, 3 gauges, one for height of watling, one for length of pickets, and one for diameter of gabion, 1 wooden mallet. One grindstone, one rubstone, and one whetstone are needed for every 25 men. One non-commissioned officer can superintend 25 men.

126. **Weight.**—The weight of a wicker gabion varies from 36 to 56 lbs. according to the size and dryness of the brushwood.

127. **Form for Hoop Iron Gabions.**—To make a hoop-iron gabion, describe a circle 2′ in diameter on a wooden platform. Divide the circumference into six equal parts (half the number of stakes to be used in the gabion). At each of these points insert wooden pins about 5″ long. Wrap the hoop iron tightly round the pins, thus forming a polygonal hoop. Mark the point where this hoop is to be riveted. Then remove it from the form, and punch and rivet it. As the iron is usually 1″ wide, 33 of these hoops will be required for a gabion.

The stakes are usually made from pine plank 1″ thick; their cross section being a triangle with 3 or 4 inches base and 1″ altitude. This is the best form, though round stakes may be used.

128. **Construction of Hoop Iron Gabions.**—To set up the gabion, place a hoop on the ground and a second directly over it, the first as represented by the dotted, the second by the full lines in Fig. 53. Insert a stake in each of the triangular spaces, then place the remaining hoops alternately over the first and second. Drive nails in four of the stakes over the exterior hoops to keep them from coming o ff.

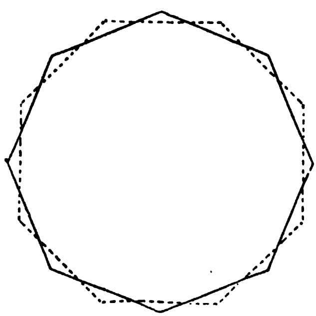


Fig. 53.

129. **Qualities of Hoop Iron Gabions.**—The hoop iron gabion is much stronger and more durable than the wicker one, but it is liable to splinter dangerously, and is heavy, weighing about 55 lbs.

SAP-ROLLER.

130. **Description.**—The sap-roller (Fig. 54) is a hollow cylinder, formed by making two concentric gabions, each 7′

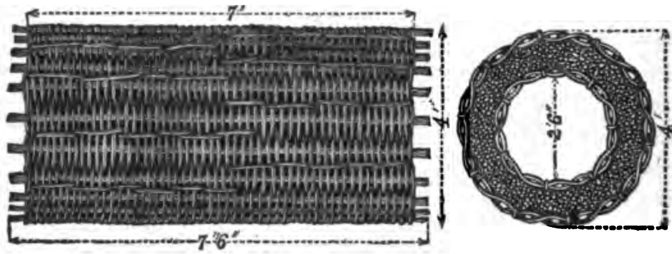


Fig. 54.—Sap-roller.

long, one 4′ in diameter, and the other 2′ 6″ in diameter, and stuffing the interval between the two with rods from 1 to 2 inches in diameter. It is used to cover the head of a sap.

131. **Pickets for Sap-rollers.**—The pickets should be of squared stuff, 7′ 6″ long and 1½ by ¾ inch in cross section. Twenty are required for the outer gabion and 14 for the inner.

132. **Construction of Gabions for Sap-rollers.**—These gabions are watled in the same manner as the ordinary gabion when the form is not used, the pickets being driven into the ground in circles respectively of 3′ 9″ and 2′ 3″ diameter. The rods should be about 1″ in diameter, carefully trimmed, and in working them in very great care should be observed to keep the web perpendicular and circular. A hoop of the same diameter as the gabion is sometimes used, which is lashed to the pickets at first half-way up, but as the web increases in height

it is pushed up to the top. The web of the gabions being completed, all the projecting parts inside and outside are carefully cut off, and the ends are sewn with wire, if procurable, or with withes as with ordinary gabions. The outer gabion should be sewn in 8 places at each end, and the inner one in 6 places.

133. **Stuffing the Sap-roller.**—The gabions should then be raised on end, one inside the other, and stout fascine rods 7′ long dropped between them, as close together as possible, by two men standing on planks supported by barrels. When these men have stuffed in as many rods as they can, the sap-roller is laid on the ground, and the stuffing completed by driving in rods from both ends until the space between the gabions is quite full, when the ends should be cut square with a saw. Care should be taken to keep the gabions concentric, and to drive the rods the whole length of the sap-roller.

134. **Men, Time, &c., in making Sap-rollers.**—Five men can make the outer gabion in 9 hours; three men watling and two preparing brushwood. The inner gabion occupies 4 men for 6 hours, three of them watling and the fourth preparing brushwood. Of the three men watling in each case, two work outside and one inside the gabion. The stuffing should be completed in 5 hours, the total time of making a sap-roller being 14 hours. A 7′ sap-roller weighs when new 14 cwt.

The tools will be the same as for gabion making, with the addition of a hoop 4′ in diameter and one 2′ 6″ in diameter.

HURDLES.

135. **Hurdles.**—Wicker-work hurdles are occasionally useful for military purposes, a good size being 6′ long and 2′ 9″ high. An even number of pickets, usually 10, similar to gabion pickets, are used. The rods for the web should be about 1″ in diameter.

136. **Construction of Hurdles.**—A circle with a radius of 8′ is described on the ground, an arc of 6′ measured off, and this arc divided into 9 equal parts. A picket is driven at each point of division, the extreme pickets being rather stouter and longer than the others, as they are afterwards required for supporting the hurdle.

The first course is laid by pairing rods, as in gabion making, beginning at the bottom and at the middle. The other courses are put on by the method of randing, as working with a single rod is called. Two men work at the web, one holding the pickets, the other randing. The thick end of the rod is placed between two of the centre pickets, the other end being taken alternately in and out between the other pickets, until it reaches the outside picket, round which it is twisted, turned, and woven back to the centre, being consequently on the oppo-

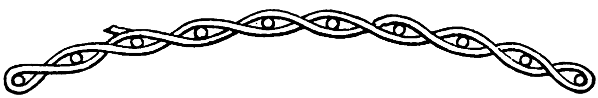


Fig 55.

site side of the pickets to that it was on before. (Fig. 55.) In working in a new rod it should always be laid alongside the

Fig. 56.—Hurdle Complete.

rod it is to replace, for four or five pickets. At the centre and top of the hurdle a course is paired with two rods as at the bottom. Fig. 56 shows a hurdle completed.

137. **Men, Time, etc., for making Hurdles.**—Three men can make a 6′ hurdle in 2½ hours. Two of them make the web, the third prepares the rods. The hurdle weighs about 56 lbs. The tools required for each party are 2 hatchets, 2 gabion knives, 1 wooden mallet, 1 measuring rod, 1 hand-saw. One grindstone, etc., are needed for every 25 men.

138. **Remark.**—Hurdles are made on a curve that they may afterwards be flat, as those which are built in a straight line frequently become crooked.

139. **Continuous Hurdles.**—Continuous hurdles may be used for revetting long lines of parapet. In such cases the hurdles should be made in the position they are to occupy, the pickets being driven into the ground as close to the parapet as possible, sufficient space merely being left to allow of the randing of the web. The pickets should be tied back to strong stakes buried in the parapet.

PICKETS.

140. **Tracing Pickets.**—Tracing pickets are 18″ long and 1″ in diameter. When they are to be used in the dark, they should be barked or whitened. They are tied up in bundles of 25 each. Each bundle weighs about 7 lbs., and can be made by one man in about an hour, his tools being a hatchet and a chopping block.

SAND-BAGS.

141. **Description of Bags.**—Sand-bags are usually made of coarse canvas or bagging. When empty they are 2′ 8″ long, and 1′ 4″ wide, and when quite full contain 1 cubic foot of

earth. In practice, however, 1 cubic yard is sufficient to fill from 48 to 50, when their average size will be 1′ 6″ to 1′ 8″ long, 10 or 11 inches wide, and 6″ thick. Each one is provided with a strong cord passed through eyelet holes near its mouth, to tie it with when filled.

142. **Filling Sand-bags.**—For filling sand-bags the working party is divided into squads of 6 men, 2 with shovels, 1 with a pick, 1 to hold the bag, and 2 to tie. Each squad fills 150 bags per hour.

SECTION IX.—PARALLELS AND APPROACHES.

GENERAL DESCRIPTION—DETAIL OF WORKING PARTIES—TRACING—EXTENDING WORKING PARTIES—EXECUTION BY SIMPLE TRENCH—TRENCH RAILWAYS.

GENERAL DESCRIPTION.

143. **Trenches.**—To obtain speedy cover from an enemy's fire, a parapet is formed from a ditch within termed a trench, of sufficient depth, with the height of the parapet, to give shelter to troops standing in the trench. Trenches are divided into two principal classes: approaches or boyaux, and parallels.

144. **Approaches.**—The approaches serve simply as covered communications which lead towards the points of the defence upon which the attack of the besiegers is directed. They are run in a zig-zag, or in a straight line, towards one or several of these points.

145. **Parallels.**—The parallels are designed as stations for troops to guard the besiegers' works and the workmen employed in their execution from sorties. Their general direction is parallel to a line connecting the most salient points of that portion of the defences attacked.

146. **Definition of Sap and Simple Trench.**—The parapet in both may be either revetted with gabions, or without revetment. In the former case, that portion of the trench executed by the first relief of workmen is called a sap; in the latter a simple trench. The simple trench is used until it has been pushed forward to within destructive range of case shot; after which the sap is employed.

DETAIL OF WORKING PARTIES.

147. **Work of an Ordinary Laborer.**—It is generally estimated that an ordinary laborer can excavate and throw out 1 cubic yard per hour of gravelly earth.

148. **Work of Soldiers.**—In all siege operations some time will necessarily be lost in extending the men, waiting for the command to begin work, &c., to say nothing of the interruptions caused by the enemy's fire and sorties. The estimate of 8 cubic yards per man in 8 hours therefore requires considerable reduction, and not more than half that quantity is to be expected from each man under the most favorable circumstances.

149. **Calculation of Number of Workmen.**—The siege night of 24 hours, reckoning from dusk to dusk, is usually divided into periods of 6 or 8 hours each, called reliefs. In calculating the number of men required for a certain piece of work, soldiers of the line may be considered equal to a task of from 100 to 150 cubic feet of earth in a relief, throwing the earth a horizontal distance of 12′, and lifting it out of a trench

from 3′ 6″ to 5′ deep. When earth has to be removed a greater horizontal distance than about 12′, shovellers should be provided in the proportion of from 3 to 4 shovellers to every 6 diggers.

150. **Detail of Working Parties.**—Working parties should, if possible, be detailed by companies, battalions, brigades, and divisions. Whenever time and circumstances permit, it will be found best to work by the task, thus doing away with a great amount of supervision. The officers and non-commissioned officers of the working parties are responsible for the amount of work done, the duty of the engineers being to see that the labor is properly applied. It is of vital importance that this responsibility of the regimental officers should be clearly understood. The chief engineer should therefore apply to the commanding general to issue a general order to that effect, before the opening of the trenches.

TRACING.

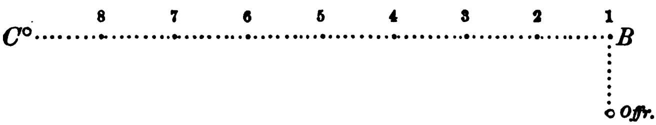
151. **Definition.**—At a siege, before working parties can be posted for the operation of breaking ground, or the opening of the trenches, it is necessary to mark the first parallel and the approaches to it on the ground in such a manner that they can be seen at night. The operation of marking out works is called tracing.

152. **Reconnaisance.**—The front of attack must first be well reconnoitered, and the distances of certain points from the most advanced works accurately ascertained by day; from which fixed points the engineers who are to trace the parallel may measure forward towards the place until they reach the exact position of the parallel. If an accurate plan of the place can be obtained, it will be very useful; but its accuracy must be tested by actual observation.

153. **Tracing Tape.**—The lines are marked on the ground by means of white tracing tapes. Each tape is 50 yards long, and should be marked at intervals of 6′ with short pieces of tape sewn on it. It is wound upon a white picket, and has loops of cord at its ends for fastening it to a picket or to another tape.

154. **Time for Tracing.**—A parallel would probably be traced by parties working right and left, from one or more points fixed in it during the day. Each set of approaches would probably be traced by a different party. The tracing should be completed before night comes on, and should not be commenced until twilight; the first to avoid great difficulty and confusion, and the second for the safety of the tracing parties and to keep the enemy as long as possible in ignorance of the front of attack.

155. **Tracing the First Parallel.**—Each tracing party consists of one engineer officer, one non-commissioned officer, and some sappers, their number being determined by the length to be traced by the party, one sapper being required for every 50 yards or fraction thereof.



The party parades at the required hour in single rank, each sapper being provided with a tracing tape, and the non-commissioned officer with a lantern, a mallet, and a picket. The officer, followed by his party marching in file, advances upon the point in the parallel from which he is to commence tracing. (Fig. 57.) On arriving at this point, *B*, he orders the leading man to halt, and takes the end of his tape from him. He marches along the line of the parallel,

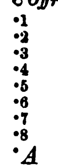


Fig. 57.

followed by the remainder of his men, while the man who has halted drops the ball, and lets the tape run out through his hands until it comes to an end, when he pushes the picket into the ground between his heels. The officer places the second tape-bearer at the end of the first tape, takes the end of his tape, and the tracing is continued as before. The ends of the adjoining tapes are secured by the same picket. The portion of parallel represented in the figure is supposed to be 400 yds. in length, and to have been traced by 8 tapes. Both parties must keep the tape near to the ground in windy weather, and take care that it be not pulled away from the tape-bearer, when nearly expended.

156. **Posting the Sappers as Markers.**—When the tracing is completed, the sappers face the point from which the working parties are to arrive, and act as markers. They hold themselves in readiness to extend the working parties as they come up, lying down in the meantime. They are not to leave their posts on any account before the working parties are properly distributed along the whole line. The officer returns to meet the working parties, and to conduct them to their proper positions.

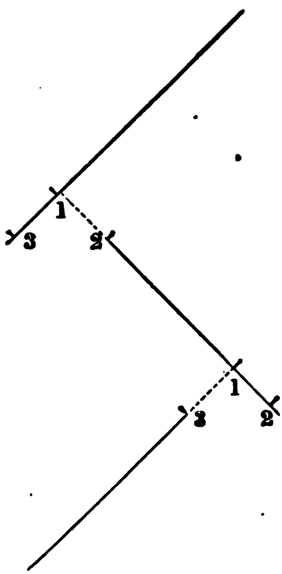


Fig. 58.

157. **Tracing the Approaches to the First Parallel.**—In tracing approaches the same method is followed. One engineer officer is employed in laying down the tapes, and posting the markers. At the angular points of the zig-zags a spare

marker is placed with three pickets, one of which he plants at the angle, and makes the tape fast to it. He then cuts the tape at a point 15′ from the angle, and extends it in prolongation of the next branch in front. The remaining two pickets are used to secure the ends of the tape after being thus cut.

This arrangement, which is represented in Fig. 58, serves to mark the returns, which are necessary at all the angles of the zig-zags. The dotted lines show the first positions of the small portions of the tape, that are afterwards cut off and moved. The figures 1, 1, represent the positions of the original pickets, which mark the angles. Figures 2 and 3 are the pickets afterwards driven to mark the extremities of the branches, after the returns 1, 3, have been traced. These returns are made a few feet further in the same direction, to conceal the approaches and cover them from enfilade fire. Their total length should be 10 or 12 yards.

158. **Direction and Length of Zig-Zags.**—Each branch of the zig-zags should receive such a direction as not to expose it to enfilade fire from any point of the defences. Its prolongation should therefore fall outside of the most advanced salient of the collateral works. As a general rule, it should not be over 100 yards long.

159. **Tracing 2d Parallel and Approaches.**—The tracing of the 2d parallel and the approaches to it is exactly similar to that of the first. Frequently the approaches are pushed forward in front of the first parallel to the intended position of the second parallel before the latter is commenced, in which case the tracing of the parallel is greatly facilitated. When the flying sap (see next section) is employed in the approaches, as it generally is in front of the second parallel, and sometimes immediately in rear of it, it is not necessary in tracing to cut the tape at the angles for the purpose of forming a return. Instead of that, four pairs of gabions, after they have been

placed by the working parties along the tracing lines, are moved in continuation of the advanced portion of the approach,

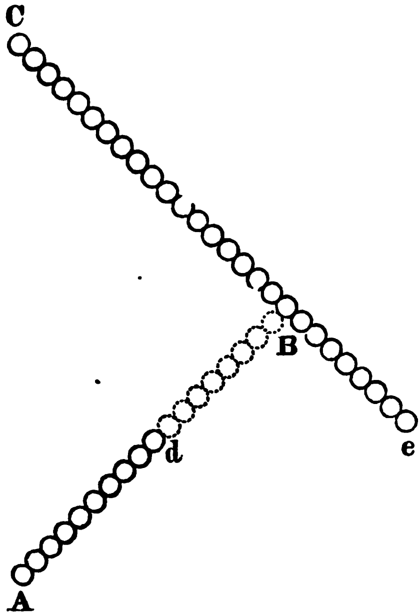


Fig. 59.

as in Fig. 59, where the gabions first placed along *Bd* are removed and placed along *Be* in prolongation of *BC*.

EXTENDING THE WORKING PARTIES ON THE LINE OF A PARALLEL.

160. **Laying out the Tools.**—The tools for the working parties are laid out for them beforehand at the depot, in rows 4′ apart, to permit of men being formed in single rank between them. Each row should contain

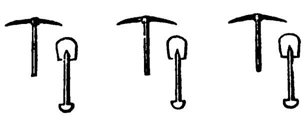


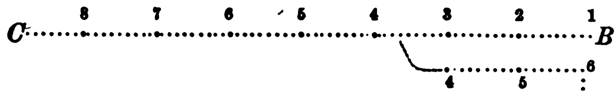
Fig. 60.

25 pairs of tools. The pick is placed on the left of the shovel and a little in front of it. (Fig. 60.)

161. **Formation of Working Parties.**—Working parties are paraded an hour and a half before sunset, at the depot; for parallels they are formed in close columns of divisions of 25 men, single rank. Each division should be commanded by a captain, or lieutenant, assisted by a due proportion of non-commissioned officers; and every battalion furnishing the working parties should also send superior officers, one to command the whole, others to superintend small divisions. A sapper is placed on the flank of each division, with a 6′ rod.

162. **Taking Tools.**—The columns are then marched on their tools, the men form in rear of each pair, and at the command *Take up Tools*, each man advances the right foot, stoops down and takes up the pick in his left hand, the shovel in his right, iron to the front, and carries them at a trail, point of the pick downwards, and blade of the shovel in a vertical plane. When all the men are provided with tools, each division is successively marched off by the right or left flank, the sapper leading. The remaining divisions wait until each preceding division has moved off. The engineer officer must be at the head of the first division, to guide it to that point in the parallel where the first marker is stationed, and from which the extension is to begin.

163. **Extending the Working Parties.**—On reaching this point, the whole of the working party forms line to the left or right, in extended order, in rear of the white tape. Fig. 61 shows this operation. The working party is supposed to be formed in close column in single rank at A. From A they are supposed to move forward by filing from the right of divisions to the point B, when the first division begins to form up into line in extended order, in the direction B C, marked by the white tape, the other divisions changing direction to the left as



they reach the point B, and continuing in the new direction until it comes their turn to form up. Each division commences its formation as soon as the head of it reaches its own marker. In the figure the first two divisions are supposed to be properly formed; the third is represented in the act of forming. The sapper, as the men form up, measures off portions of 6′ along the tape, and each man with his left hand drives his pick into the ground on the left of his own task. The shovel is then placed on the ground parallel to and in rear of the tape, the centre of the shovel being opposite the centre of the 6′ portion. (Fig. 62.) The engineer officer superintending is to watch over the whole of this extension with great care. He must not allow any man of the working party to take post behind the tape, until the sapper is

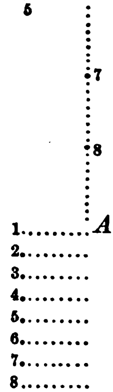


Fig. 61.

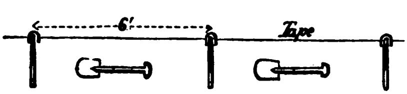


Fig. 62.

ready for him; and he must see that the latter does not move on until each successive workman is properly posted. As soon as each workman has placed his tools, he will sit or lie down behind them, and wait for the order to begin work, in perfect silence.

If the working party be armed,* each man places his arms on the ground three paces to the rear. It is not advisable to

*The working parties should usually go without arms when they are to be greatly dispersed, as in the construction of parallels and approaches by simple trench. In the construction of batteries they are more concentrated, and it may be advisable for them to carry their arms with them.

extend more than 400 men from one point. About 100 men can be extended in 5 minutes. There will be two sappers to every party of 25 infantry; viz., one who traced and one who brought up the working party; their duty is to explain the extent of the tasks, show the men how to handle their tools, and see that the work is properly executed.

164. **Extension of 2d and 3d Reliefs.**—Each man of the first relief, after completing his task, scrapes his tools and lays them together in rear of the trench, the sappers seeing that they are properly placed. In order to encourage the men to exertion, each division should be allowed to return to camp on the completion of its task. One sapper of each party remains with the tools; the other goes for the 2d relief. The second and third reliefs are extended in rear of the trench already executed, in the same manner as the first relief. The sappers are relieved at some time intermediate to the reliefs of the working parties, to avoid confusion.

EXECUTION OF PARALLELS BY SIMPLE TRENCH.

165. **First Parallel in Difficult Soil. First Relief.**—When the first parallel is made in difficult soil, the first relief has to dig a trench 6′ long measured on the tracing tape, 4′ 6″ wide, 3′ deep in front, and 3′ 3″ in rear, throwing the earth in

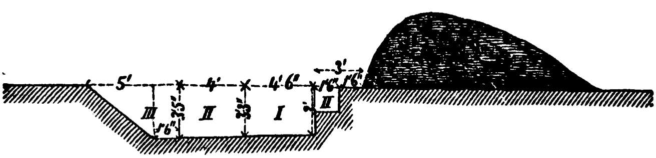


Fig. 63.—Parallel in Difficult Soil, Three Reliefs.

front of the tracing tape and 3′ from it. (Fig. 63.) As soon as all the men have marked their tasks, the tape is removed

and wound up by the sappers, the pickets being left in the ground. Each man begins by digging a hole 2 or 3 feet in diameter at the left of his task to the full depth, so as to obtain cover speedily, and then proceeds to lengthen it to obtain a through communication, after which he will widen the trench to its proper dimensions. Fair cover should be obtained within an hour.

166. **Second Relief. Hour for Extending.**—In the construction of parallels and approaches, the 2d relief must never enter the trenches before day-break; and the 3d relief, when three are employed, should enter them at noon. Hence in the long summer days of northern climates, the twenty-fours may be divided, for the reliefs, into three equal periods of 8 hours each. This necessity for waiting till daylight before the 2d relief is set to work, does not exist in the other operations of a siege, for the men are either more concentrated on particular spots, as in the construction of batteries, or more subdivided at the same time that fewer are employed, as in the execution of the final operations, most of which are commenced by the regular sap or by mining, and there is therefore much less danger of confusion.

167. **Task of Second Relief.**—The second relief, then, is extended at daybreak, the tools left by the 1st relief being already on the ground. Each division will begin work independently, without waiting for the others. This relief has to widen the trench executed by the 1st relief 4 feet, making it 3′ 5″ deep at the rear, and to cut away 18″ of the berm* left by the first relief, to a depth of 18″, for the front step of the parallel.

168. **Third Relief.**—The third relief widens the trench 5′ at top, and 1′ 6″ at the bottom, making the extreme depth

* The berm is the space at the foot of a parapet, left clear of earth, so that the weight of earth may not break in the edge of the excavation.

at the rear 3′ 6″. Their task is made considerably less than that of the other reliefs, as they have to throw the earth much farther, make the necessary drains, and finish off the trench.

169. **Parallel in Easy Soil.**—In easy soil the parallel can be executed in two reliefs. The first relief makes a trench 6′ 6″ wide, 3′ deep in front, and 3′ 4″ in rear. The 2d relief widens the trench 7′ at top, and 3′ 6″ at the bottom, besides forming the front step. Figure 63 shows the dimensions of the work to be done by each relief in difficult soil. Figure 64 shows the same in easy soil.

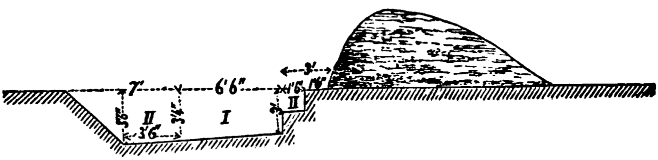


Fig. 64.—Parallel in Easy Soil, Two Reliefs.

170. **Approaches in Difficult Soil.**—Approaches are formed in the same way as the parallel, but when very oblique to the enemy's fire it becomes necessary to deepen them so as to obtain more cover; and, being more used as thoroughfares, they are frequently made a little wider. (Fig. 65.) When made in difficult soil and of this profile, the first relief excavates a trench 4′ wide, 3′ 6″ deep in front, and 3′ 8″ in rear, throw-

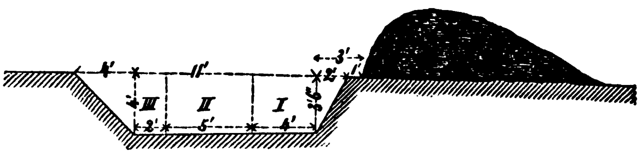


Fig. 65.—Profile of an Oblique Approach, Difficult Soil.

ing their earth 3′ to the front, and afterwards cutting away 2′ of the berm at the top to make the front slope; the second relief widens the excavation 5′, while the third relief widens the

whole 6′ at the top and 2′ at the bottom, making the depth in rear 4′.

171. **Easy Soil.**—In easy soil the first relief excavates a trench 6′ wide in rear of the tracing line, throwing the earth 3′ to the front, and afterwards cutting away 2′ of the berm at the top; the second relief finishes the excavation according to the profile in Fig. 65.

172. **Second Parallel.**—The second parallel being commenced by flying sap is described in the following section.*

173. **Trenches on Unfavorable Ground.**—In the foregoing descriptions of trenches, it has been assumed that the fortress attacked is situated on an extensive plain, over which it has but a moderate command, and that the soil is neither marshy nor rocky. Modifications in the profile must be made when the conditions are unfavorable.

174. **Trenches against Fortress on a Hill.**—When the

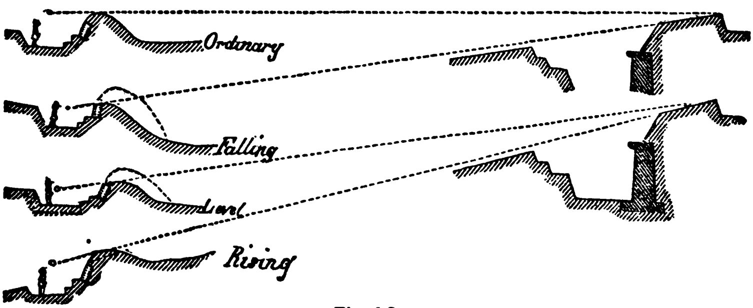


Fig. 66.

fortress is situated on a very commanding eminence, it is evident that the trenches, if on level ground, must be made

* By second parallel is meant the conventional second parallel; *i. e.*, the parallel which is within destructive range of case shot. In modern sieges as many as 7 parallels have been found necessary.

deeper, and have higher parapets, than those shown in the foregoing figures. Any ground rising towards the fortress should, if otherwise suitable, be chosen for the position of trenches, and more especially of approaches; and on the contrary, ground falling towards the fortress should, if possible, be avoided, so that the height of the parapet may not require to be increased. (Fig. 66.)

175. **Trenches on Marshy Ground.**—Supposing water to be found near the surface, it will be necessary to make the trench shallower, and its parapet higher, and perhaps to cut a ditch in rear or front for drainage, and for the supply of the necessary earth. (Fig. 67.)

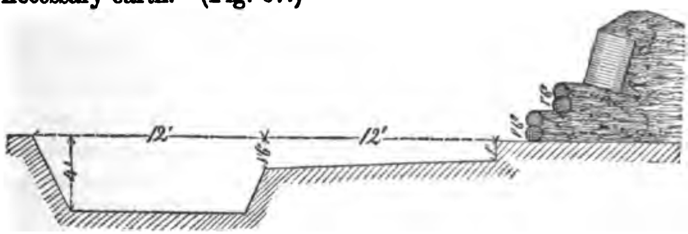


Fig. 67.—Trench on Wet Soil.

176. **Trenches on Rocky Ground.**—If rock be found near the surface, the trench must, as in the last case, be made shallower and wider, and the parapet higher. In some places (as occurred at Sebastopol) it may be impracticable to dig down at all, and the parapet must be formed of earth brought up in sand-bags from the nearest point.

A path from the depot of sand-bags to the trench should be selected and distinctly marked. The carriers march along the path in single file, each carrying a filled bag on his shoulder; on arriving at the head of the trench, he delivers the sand-bag to the sapper and returns for another. The bags are all laid perpendicular to the direction of the trench (*i. e.* as headers), and with their mouths alternately out and in.

The parapet is executed as follows: the 1st sapper, kneeling, places the first four courses marked 1 (Fig. 68). When he has laid a distance of 12 bags, the 2d sapper, also kneeling or stooping, lays the four courses marked 2. The 3d, 4th, and 5th sappers lay the courses marked 3, 4, and 5. The 6th lays the portion marked 6, a seventh sapper standing on the banquette and passing the bags up to him. Every two sappers require a carrying party.

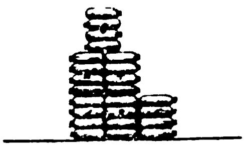


Fig. 68.

By a combination of gabions and sand-bags, the parapet may be constructed with greater rapidity and a less number of bags. The gabions are placed as in the ordinary flying sap, and filled with sand-bags by a party of carriers. The bags for this purpose should not be quite full, in order that they may lie closer in the gabion. The sand-bags for increasing the height and thickness of the parapet are laid in a manner similar to the preceding case. (Fig. 69.)

Fig. 69.

177. **Steps over Parallels.**—As it is desirable that the guard of the trenches should have the means of advancing with an unbroken front to repel sorties, portions of the parallel should be provided with steps about 18″ high, revetted with a

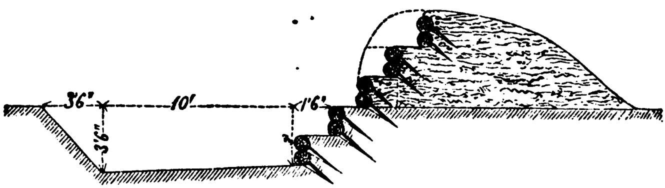


Fig. 70.—Steps over Parallel.

couple of fascines, one above the other. Fig. 70 represents this arrangement in a parallel made by simple trench, and Fig.

71, in one constructed by the sap. In the latter case, as the top of the gabions must form the second step above the ground

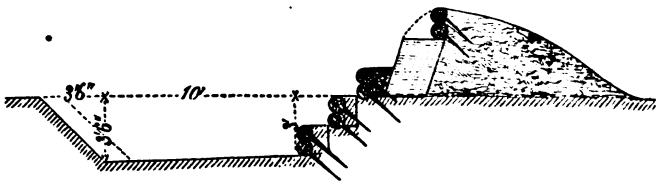


Fig. 71.—Steps over Parallels.

line, the three lowest steps will each have to be formed 18″ further to the rear than in the former case, the earth for these steps being obtained by widening the trench to the rear, so as to preserve its full width. In this case the 2d relief should not form the steps as usual, but leave a berm 3′ wide.

178. **Men and Tools for Executing 1,000 Yards of Simple Trench.**—For throwing up 1,000 yards of parallels and approaches by simple trench, there will be required for each relief, 2 engineer officers, 2 non-commissioned officers of engineers, 20 sappers, 20 non-commissioned officers of infantry, and 500 privates. Their tools will be 520 pickaxes, 520 shovels, 20 six-feet measuring rods. The extra picks and shovels are to replace breakages, and are carried by the non-commissioned officers of the working parties.

Where obstructions occur in the line of a parallel, such as watercourses and roads, a few more sappers and infantry will be required. As a general rule, the surface of a road should not be disturbed without special authority, but a parapet should be formed across it.

TRENCH RAILWAY.

179. **Portable Railway.**—In the present day, when rifled guns of large calibre are used, and the range of the guns in a fortress is so greatly increased, it becomes necessary to provide

some improved means of transportation to the front, for the vast quantities of material and ammunition that will be required. For this purpose the portable railway, now in common use in this country, should be supplied.

SECTION X.—SAPS.

FLYING SAP—SINGLE SAP—DOUBLE SAP—HALF-DOUBLE SAP—HALF-SINGLE SAP.

180. **Different Kinds of Saps.**—There are four kinds of sap in general use.

Flying Sap.—For obtaining cover quickly in forming parallels, approaches, or lodgments, when simple trench cannot be used.

Single sap (often called Full Sap).—For pushing on parallels, &c., under heavy musketry fire.

Double Sap.—A combination of two or more single saps, for pushing on approaches when single sap cannot be employed, owing to cross fire.

Half-double Sap.—For forming lodgments on the crest of the glacis, which have to be protected both from direct fire and the reverse fire of the collateral works of the place attacked.

In addition to these, the Half-Single Sap is occasionally used when the enemy's fire is nearly perpendicular to the direction of the sap.

FLYING SAP.

181. **Carrying Tools, &c.**—Flying sap is executed by infantry. Each man carries two gabions, holding them by means of the carrying pickets well up under each arm, with a shovel in the right gabion and a pick in the left. (Fig. 72.) The blade of the shovel must be secured between two of the gabion pickets, and the point of the pick pushed under the pairing rods to prevent it from slipping. The implements must be previously laid out at the engineer depot, in rows 6′ apart from centre to centre, the picks and shovels being carefully placed in the gabions as above.

Fig. 72.

182. **Extension of Working Party in Flying Sap.**—The mode of extension is the same as for the first parallel, except that no marks on the tape are necessary; the two gabions carried by each workman mark his task. As they come up into their proper places on the reverse side of the tape, the men will successively put down their gabions close together in front of the line, clearing it by 2 or 3 inches, and taking care that the gabions touch each other, and that no space is left between them and the gabions already placed. The sapper corrects the position of every successive pair of gabions.

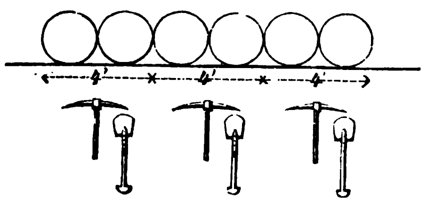


Fig. 73.

Each man then takes out his tools and the carrying pickets, places his tools in rear of the gabions (Fig. 73), and lies down.

As soon as the gabions are placed, the tracing tape is removed 3′ from the base of the gabions, to mark the front of the tasks.

183. **Execution of 2d Parallel by Flying Sap.**—When all the party are extended, and the engineer officer has satisfied himself that all the gabions are properly placed, he gives the word "*Commence Work,*" which is passed on quietly by officers and non-commissioned officers in charge of working parties, and then every man excavates in rear of his own two gabions, and 3′ from them. He makes a hole at the left of his task, large enough to stand in, to the full depth of 3′, so as to obtain cover as soon as possible, and then enlarges the trench, dropping the earth into the gabions. When each gabion is about half full, the heads are pushed outwards, the sapper taking care that they have a slope of about $\frac{1}{4}$; they are then filled. When the gabions are filled, the earth excavated is thrown just over them so as to cover them, and, as soon as this is done, the remaining earth is thrown as far to the front as possible, so as to make a good base for the rest of the parapet, and to prevent the second and third reliefs having to throw the earth excavated by them too far or too high.

184. **Tasks of Each Relief in Executing 2d Parallel.**—The profile of the 2d parallel is shown in Fig. 74, and is the

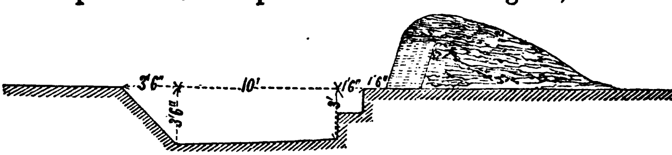


Fig. 74.—Profile of Second Parallel.

same as that of the first parallel, except that it is revetted with gabions. The tasks done by each relief are the same as in the first parallel, except the first relief, in which the men work at 4′ intervals. The 2d and 3d reliefs work at 6′ intervals, and are only two-thirds the 1st in numbers. Consequently every third man of the 1st relief will return his tools to the

engineer depot. The carrying pickets and the tracing tapes should be collected by the non-commissioned officers, and returned with the other tools to the depot. The tools left by the 1st relief are placed by the sappers in rear of each 6′ portion.

185. **Detail of Men and Tools for Executing 2d Parallel.**—The men and tools required for throwing up 1000 yards of parallels or approaches, commenced by flying sap, are for the 1st relief, 2 engineer officers, 2 non-commissioned officers of engineers, 30 sappers, 30 non-commissioned officers and 750 privates of infantry, with 780 pickaxes, 780 shovels, 30 six-feet measuring rods and 1500 gabions. For the 2d and 3d reliefs, 2 engineer officers, 2 non-commissioned officers of engineers, 20 sappers, 20 non-commissioned officers and 500 privates of infantry, with 520 pickaxes, 520 shovels, and 20 six-feet measuring rods. The extra picks and shovels are to replace breakages, and are carried by the non-commissioned officers of the working parties.

SINGLE SAP.

186. **Description.**—This is a path executed by sappers, who advance foot by foot, covering themselves from the fire of the place by gabions, which are placed and filled in succession, and by a sap-roller placed at the head of the sap.

There are two kinds of single saps; viz., the Kneeling and the Standing. The kneeling sap has the great advantage over the standing sap, that it advances half as quickly again; but it has the disadvantage that the thickness of earth to cover the sapper is not so great.

187. **Right-handed Sap.**—Saps are called right or left handed, according to the direction in which they run; if to the right, when facing the enemy, it is a right-handed sap, and the sappers use their tools in the ordinary way that a right-handed man does; viz., with the right hand at the end of the

shovel. In a right-handed sap the parapet is on the left of the sappers working in the sap; the left is then called the pivot flank, and the right the reverse flank.

188. **Left-handed Sap.**—If the sap runs to the left, when facing the enemy, it is a left-handed sap, and the sappers must hold the end of their shovels in their left hands, and throw the earth to their right flank.

189. **Flying Sap to be resorted to when Practicable.**—In all saps, both single and double, advantage should be taken of any slackness of the enemy's fire, to push them on more rapidly by flying sap, moving the sap-rollers forward and filling the intervals with gabions.

190. **Tools, Sap-fork.**—The tools employed are short-handled picks, and shovels, sap-forks, and drags. The sap-fork

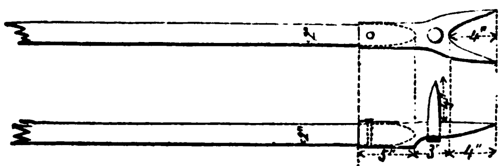


Fig. 75.—Sap-Fork.

(Fig. 75) has three points, the two extreme ones being parallel and 4″ apart, the middle one at right angles to the plane of the two others. The length of the iron part is 1′, 4″ for the point, 3″ for the body, and 5″ for the socket. The handle of forks for one purpose is 11′ 8″ long, is fastened into the socket with a rivet, and carries at its other end a ring 1½″ in diameter. For another purpose the handle is 5′ long.

191. **Working Party for Kneeling Sap.**—A brigade of one non-commissioned officer and eight sappers is required for each sap-head pushed by kneeling single sap. In all saps half the men only of each brigade actually work at a time; the other half rest, but must keep the men who are at work supplied

with materials. A sap-head must always be pushed on steadily and vigorously; casualties among the men at work must be at once made good from the men not at work, and, unless a brigade be reduced to less than four, it will have to continue without any additional sappers to push the sap-head for the rest of its relief of eight hours. If, however, it should be found necessary, two or more infantry soldiers may be obtained from the party widening the sap, to pass up gabions, &c., and sometimes to take permanently between them the place of No. 4 sapper. The men are called No. 1 sapper, No. 2 sapper, &c., according to the positions they occupy in the sap, No. 1 being always the one at the head of the sap, No. 2 the one next to him, and so on. The men do not retain their numbers long, but change posts whenever the sap has advanced two gabions, No. 1 becomes No. 2, 2 becomes 3, 3 becomes 4, 4 ceases to work and becomes No. 5, 5 becomes 6, 6 becomes 7, 7 becomes 8, and No. 8, the sapper who has been resting longest, becomes No. 1.

192. **Breaking out a Single Sap.**—The point in the parallel from which the sap is to be broken out being determined, six gabions are removed during the day, and as much of the parapet and solid ground cut away as can be done without disturbing the crest of the parapet. (Fig. 76.) The earth is scattered

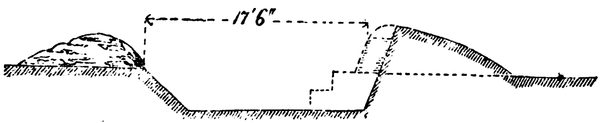


Fig. 76.—Breaking out Saps.

on the reverse of the parallel, so as not to attract the attention of the garrison. When it is so dark that the garrison cannot see the operation, the remaining loose earth is picked down to form a ramp, about 12′ wide, up which the sap-roller is rolled over the parapet by six men, and placed about 4′ from its base. (Fig.

77.) No. 1 then creeps over the parapet, with his tools, gets well under cover of the sap-roller, and receives two gabions, rolled over to him by No. 2, which he places on the circumfer-

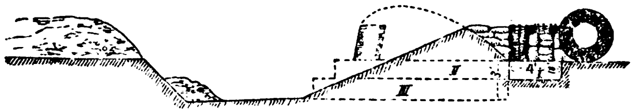


Fig. 77.—Breaking out Saps.

ence of a circle of about 14′ radius, their centres being in a line with that end of the sap-roller, at which the parapet is to be, filling each with about seven half-filled sand-bags. He also fills up the interval between the parapet and gabion with filled sand-bags laid as headers and stretchers, requiring about 12 for that purpose. A wall of sand-bags is built up against the two gabions as described in par. 201. No. 1 then digs a trench 4′ long, parallel to the gabions, 1′ 6″ wide, and 1′ 6″ or 3′ deep, according as the sap is to be kneeling or standing, leaving a berm 1′ 6″ wide at the base of the gabions, and working from the sap-roller towards the parapet, to keep himself as much under cover as possible.

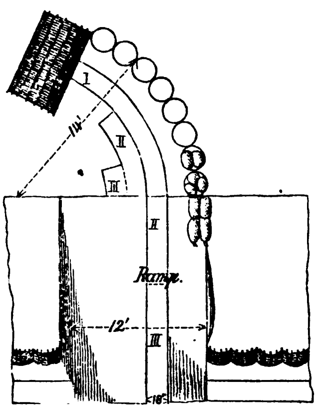


Fig. 78.—Breaking out Saps.

The other numbers work hard to make a communication through the ramp from the parallel. No. 2 excavates a trench 1′ 6″ wide and 1′ 6″ deep (below the ground line) in a line with No. 1; No. 3 follows at an interval of 5′, and deepens No. 2's trench 1′ 6″; No. 4 (in kneeling sap) clears away the earth from the reverse of the trench, and takes No. 3's place when No. 2 goes over the parapet to follow No. 1.

As soon as No. 1 has thrown

the earth out of his trench (leaving sufficient loose earth in it to fill the next gabion) he places a third gabion, No. 2 coming over to assist in moving the sap-roller forward. The numbers now change posts, and the work proceeds as described in par. 194 if kneeling, or par. 210 if standing. The other half brigade revets the communication through the parapet of the parallel, as soon as it is made, leaving the widening of it to be executed by the infantry parties.

In all single saps that are broken out of a parallel, the first nine or ten gabions are placed on a curve of about 14′ radius, so as to cover the communication through the parapet of the parallel, and to obtain width for the trench of the sap, between its parapet and that of the parallel. (Fig. 78.)

193. **Tools and Material Required for Kneeling Single Sap.**—Each brigade will require for kneeling sap 8 picks, 8 shovels, 3 pairs knee-caps, 2 long sap-forks, 1 short sap-fork, 1 6-feet measuring rod, 1 20-inch gauge, 2 18-inch gauges, 1 10-inch gauge, 1 sap-roller, and 30 sand-bags. The gauges may be cut from brushwood.

194. **Duties of No. 1.**—The first duty of No. 1, who works kneeling, is to fill the empty gabion which he finds at the head of the sap, with earth loosened for the purpose by the previous No. 1. In filling a gabion he drops the earth in carefully, and strikes the gabion with his shovel occasionally to shake the earth down in it. When he has filled the gabion, the trench should extend as far as its centre. He next continues excavating the trench towards the sap-roller, making it 18″ deep and about 18″ wide, and leaving a berm 18″ wide between it and the gabions.

Too much attention must not be paid to the dimensions, as the great object is not to leave a perfectly formed trench, but to push on the sap-head as fast as possible. If more earth be required for filling a gabion, it can be obtained by widening the trench to the reverse flank.

195. **Preparing to Place a New Gabion.**—When No. 1 has loosened earth enough to fill a gabion, to do which he must work as close as he can up to the sap-roller, he calls out *Gabion*, when an empty one is handed by No. 5 to No. 4, and passed up to the front by No. 3 and No. 2 in succession. While this is being done, No. 1 removes the four half-filled sand-bags that are in rear of the first gabion, placing them on the berm behind the third gabion, and also the two vertical sand-bags that are between the sap-roller and the first gabion, one of which he will place in the trench in front of him, and the other on the berm in rear of the second gabion. He then prepares to place the gabion by one of the following methods.

196. **Method of Placing a Gabion by Lifting.**—No. 1 stands his gabion on end, close to the sap-roller and over his trench; he then forces the two horizontal prongs of a short sap-fork between two courses of the web, about 12″ from the bottom, taking care that he does not expose his arms above the parapet while doing so; he then lowers the handle until the third or vertical prong takes a bearing on the gabion, and tries whether he can lift the gabion properly; the end of the handle should be about 6″ from the ground at the moment the gabion is lifted off it, and the handle on the reverse flank of the sapper's body. There is some difficulty in poising the gabion on the sap-fork, and No. 1 will probably have to take his sap-fork out once or twice before getting a secure hold of the gabion; when he succeeds, he calls out *Ready*.

This is the best method, but can only be managed by men with powerful arms, unless the gabions be very light.

197. **Method of Placing a Gabion by Tilting.**—The second method is by tilting the gabion up in position. No. 1 lays the gabion on its side across the head of his trench, with its reverse flank advanced slightly, so that when rolled forward the gabion may just clear the one last placed; he then takes his sap-fork and rests it on the gabion to keep it steady, the

handle being in his reverse hand, and calls out *Ready*. When the sap-roller has been moved forward about 2½ feet, No. 1 rolls the gabion forward with his sap-fork; the reverse flank of the gabion, being slightly advanced, comes first against the sap-roller, and the bottom of the gabion can therefore be easily slewed into its proper position, or very nearly so. No. 1 then places the two horizontal prongs of his sap-fork under the pairing rods at the top of the gabion, and tilts it up on end. If the ground be sloping down from the reverse to the pivot flank, No. 1 must be careful not to tilt the gabion over too violently, or it will fall on its side towards the front, and cause delay while another gabion is being brought up.

198. **Pushing the Sap-Roller Forward.**—While No. 1 is getting his gabion poised or placed for rolling, Nos. 2 and 3 take hold of the long sap-forks, unpin and get them into good positions for pushing the sap-roller forward. No. 2's sap-fork should be about the centre of the length of the sap-roller, about 3′ from the ground, and No. 3's about 4″ nearer to the reverse flank, and just above the centre of the sap-roller; in both cases the third or vertical prong must be upwards. When all are ready, the non-commissioned officer gives the word *Together, Forward,* when Nos. 2 and 3 push the sap-roller forward about 2½ feet; it will be necessary for them to pull out their sap-forks from time to time to take fresh purchases, care being taken that both are not withdrawn together.

Should the sap be going down hill, Nos. 2 and 3 will reverse their sap-forks, and prevent the sap-roller rolling away too quickly or too far, by means of the third or vertical prong.

199. **Placing a New Gabion.**—As soon as the sap-roller has been advanced far enough, No. 1 calls out *Halt*, and taking care to keep his body sheltered by the full gabions, lifts or tilts his gabion into its position, viz., touching the last filled gabion, and in the proper line; the latter will be given by the non-commissioned officer, who will say *In* or *Out* according as the

gabion has to be pulled towards the trench or pushed away from it, which must be done entirely with the sap-fork. Care must be taken to get the gabion well to the front or pivot flank, as it can easily be pulled towards the trench, but it is very difficult to push it away. Any interval between it and the last placed gabion can be lessened, if not entirely closed, by pulling back the sap-roller at the same time that No. 1 pushes with his sap-fork the top of the gabion towards the sap-roller. If this be necessary No. 1 will call out *Pull back the Sap-roller*. The non-commissioned officer is responsible for the gabion being placed with sufficient correctness, on the proper curve or on the straight line, as the case may be; too much time must not, however, be lost in aligning the gabion accurately.

200. **Securing the Sap-roller.**—The gabion having been properly placed, the non-commissioned officer gives the word *Secure the Sap-roller*, when Nos. 2 and 3 pull it back until it touches the gabion just placed. No. 1 then lays his sap-fork on the reverse flank, about 6″ from his trench, No. 2 places his sap-fork against the sap-roller (third prong up) with the two horizontal prongs about 3′ from the ground, and at about 2½ feet from its reverse end. No. 3 sticks the third prong of his sap-fork into the upper part of the sap-roller, a little above No. 2's, and pins the other end to the ground about 9″ from the reverse flank of the trench, by driving a picket through the ring in the handle.

If the sap is being driven up hill, both the sap-forks should have their horizontal prongs stuck against the sap-roller, to prevent it slipping back; and if the sap is going down hill, both sap-forks should have their third prongs fastened into the sap-roller, to prevent it running on. In both cases, both sap-forks should be pinned down by pickets driven through their rings.

201. **Sand-bag Parapet.**—Two three-quarter filled sand-bags are now passed up to No. 1, who builds them and the

sand-bags he removed before he placed the last gabion, as follows. He places two three-quarter filled sand-bags vertical, opposite the interval between the newly placed gabion and the

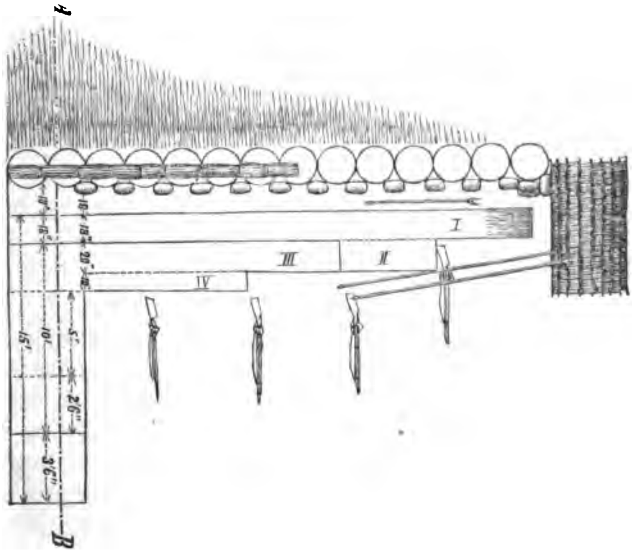


Fig. 79.—Plan of Kneeling Sap.

second gabion; two three-quarter filled vertical between the sap-roller and the newly placed gabion; and four half-filled

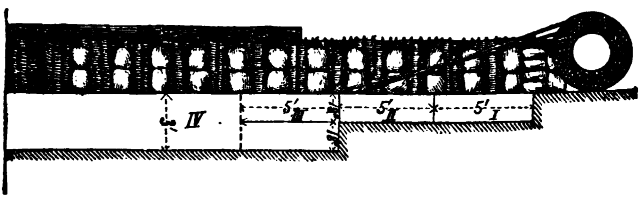


Fig. 80.—Sectional Elevation of Kneeling Sap.

ones against the newly placed gabion, and between the four sand-bags previously mentioned. (Figs. 79 and 80.)

202. **Continuation of Sap by No. 1.**—No. 1 next fills the last placed gabion with the earth he had previously loosened, and then continues his trench towards the sap-roller, until he has loosened enough earth to fill another gabion; he then calls out *Gabion*, and the work proceeds as above.

203. **Duties of No. 2 in Kneeling Sap.**—No. 2 widens No. 1's trench 20″, keeping it of the same depth, viz., 18″; he must not approach the head of No. 1's work nearer than 5′, for fear of wounding him with his pick, but he must keep as near that distance as possible, in order that he may be able to use his sap-fork conveniently when the sap-roller is being advanced. If from any circumstance, such as a vein of very difficult soil, he finds that he is unable to keep up with No. 1, he will reduce the width (not the depth) of his trench until the difficult part is passed. No. 2 works on his knees, and throws the earth he excavates just over the row of gabions and as much to his front as possible, that is towards the head of the sap, to give better cover there, where it is weakest. Before filling up against the gabions he pushes their tops outward, so as to give them the proper slope of $\frac{4}{1}$. He assists in moving forward the sap-roller, as explained above.

204. **Duties of No. 3 in Kneeling Sap.**—No. 3 deepens the trench of No. 2 18″, and keeps about 5′ from its front. He works standing, and throws his earth just over the gabions, as much towards the head of the sap as possible. He assists in moving forward the sap-roller, and passes up materials as before explained. He also crowns the sap, that is, places 6′ fascines on top of the gabions, with a short sap-fork. No gabion must be crowned before it has been completely filled, but there should never be more than six gabions uncrowned. A man on first becoming No. 3, takes off his knee-caps and gives them to No. 8.

205. **Duties of No. 4 in Kneeling Sap.**—No. 4 widens the trench 10″, down to its full depth of 3′. He works standing and throws his earth just over the crowning fascine and as much to his front as possible. He assists in passing up materials, and in moving the sap-roller up a steep hill he assists No. 3 at his sap-fork.

206. **Duties of Remainder of Brigade Kneeling Sap.**—The first duty of a sapper becoming No. 5 is to scrape his shovel and place it and his pick on the reverse of his trench, about 5′ in rear of No. 4's work. He brings up the 6′ fascines and the gabions from the place where they were left by the carrying party. He sees that there are always 12 gabions close at hand, to be ready in case the musketry fire slackens sufficiently to enable a few gabions to be placed by flying sap; these gabions should be laid on their sides on the reverse of the sap, perpendicular to the trench, the first gabion being about 10′ in rear of the head of No. 4's trench. He also fills any sand-bags that may be required. In the absence of the non-commissioned officer, No. 5 gives the words of command. Should either No. 3 or No. 4 become disabled, No. 5 immediately replaces him, and No. 6 becomes No. 5.

Nos. 6 and 7 have no work to do.

No. 8 must always have his pick and shovel close at hand, in good order, and knee-caps on. Should either No. 1 or No. 2 become disabled, he immediately takes his place, and No. 7 becomes No. 8.

The picks and shovels of the men at work, when not in use,

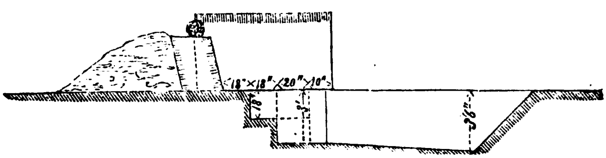


Fig 81.—Section on A B Fig. 79.

are placed, iron to the front, on the reverse of the trench oppo-

site each man's place, and the gauges are laid on the berm. The men's rifles are to be kept handy on the reverse of the trench. (Figs. 79, 80, & 81.)

207. **Number Sand-bags Required.**—The number of sand-bags necessary for the sap-head is 30, viz., 26 filled three-quarters full, and 4 half-full; of the 26, two are placed between the sap-roller and the first gabion, and the remainder at the junctions of the gabions in rear, two at each junction, placed on end one over the other. This number will cover the junctions as far back as that between the twelfth and thirteenth gabion from the front; and as the four sappers ought to work in a space of about 20′, the gabions at that distance from the sap-head ought to be well backed up with earth; if owing to any peculiar circumstances they are not, extra sand-bags may be used to cover more junctions.

208. **Rate and Materials, Kneeling Sap.** — Kneeling single sap advances at the rate of from 6 to 12 feet per hour, according as the soil is difficult or easy, and requires for each relief of eight hours, from 24 to 48 gabions, and from 8 to 16 6′ fascines.

209. **Widening Parties, Kneeling Single Sap.**—Kneeling single sap is widened by parties of infantry, in two reliefs, the men being distributed at 6′ intervals. The first relief widens the sap 5′, and make the trench 3′ 5″ deep in rear, giving a total amount of excavation per man of $96\frac{1}{4}$ cubic feet. The second relief completes the trench to a width of 10′ at bottom, and forms the reverse slope at an angle of 45°, giving a total per man of $88\frac{5}{8}$ cubic feet.

210. **Standing Single Sap, Duties of Brigade.**—Standing single sap is executed by a brigade of one non-commissioned officer and six sappers.

The non-commissioned officer and Nos. 1, 2, and 3 sappers

perform the same duties as in kneeling sap, the only difference being the section of the trenches excavated. The men all work standing.

No. 1 excavates a trench 18″ wide and 3′ deep, leaving the usual berm 18″ wide.

Nos. 2 and 3 each widen the trench by 18″, keeping it at the same depth. If, owing to any very difficult vein of soil, Nos. 2 and 3 cannot keep at their proper distances from the head of

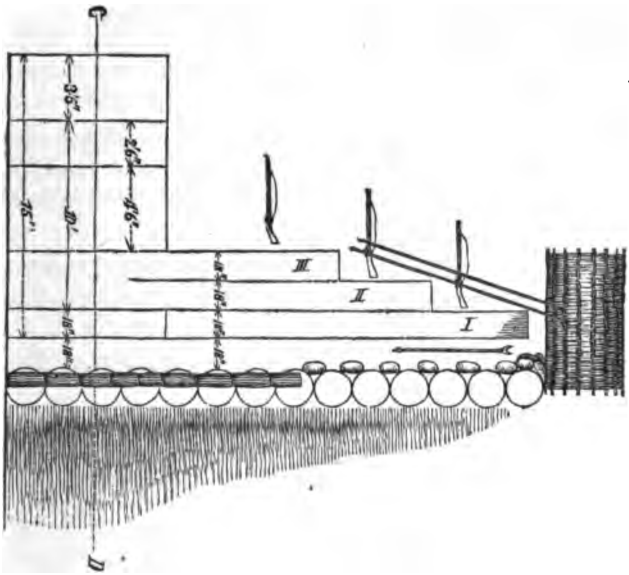


Fig. 82.—Plan of Standing Sap.

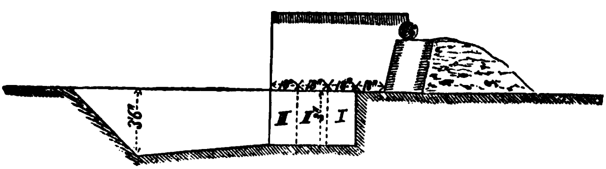


Fig. 83.—Section on CD Fig. 82.

the sap, they may diminish the width (not the depth) of their trenches, until the obstacle is passed.

Nos. 4 and 5 rest.

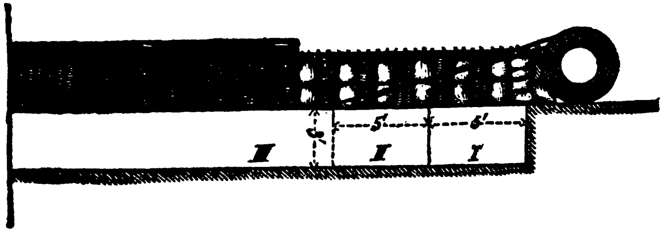


Fig. 84.—Reversed Sectional Elevation of Standing Sap.

No. 6, or the one who has been longest at rest, and who will become No. 1 on the next change of posts, must have his pick and shovel in good order and close at hand. No. 6 also assists No. 3 with the sap-fork when required. He brings up the fascines, keeps 12 gabions close at hand, and fills any sand-bags required. Should the non-commissioned officer be absent, he gives the words of command. Should either No. 1, 2, or 3 become disabled, No. 6 immediately replaces him, and No. 5 becomes No. 6.

Figures 82, 83 and 84 fully illustrate this sap.

211. **Rate and Materials Standing Single Sap.**—Single standing sap advances at the rate of from 4 to 8 feet per hour, and requires per relief of eight hours from 16 to 32 gabions, and from 6 to 11 6′ fascines. The number of sand-bags necessary for the sap is 18, which will cover the junctions as far back as between the 6th and 7th gabions.

212. **Tools.**—The tools required for each brigade are 6 picks, 6 shovels, 2 long sap-forks, 1 short sap-fork, 1 6′ measuring rod, and 3 18″ gauges.

213. **Widening Parties, Standing Single Sap.**—Standing single sap is widened out by parties of infantry, in two

reliefs, the men being distributed at 6′ intervals. The first relief widens the sap 4′ 6″, and makes the trench 3′ 5″ deep in rear, giving a total amount of excavation per man of 86⅘ cubic feet. In addition they form a step in front if required. The second relief complete the trench to a width of 10′ at bottom, and form the reverse slope, the task of each man being thus 88⅘ cubic feet.

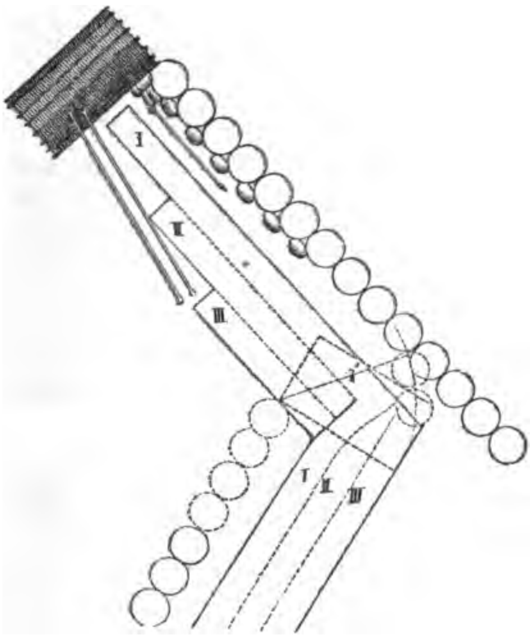


Fig. 85.—Changing Direction.

214. Changing the Direction of Single Sap.—The direction of a single sap is changed as follows:

1st. When the new zig-zag is to form an obtuse or right angle with the old one, the sap-roller is made gradually to

describe the arc of a circle with its reverse end, about its pivot end as a centre, until it is perpendicular to the new direction, when it is moved forward in the usual way.

2d. When the new zig-zag is to form an acute angle with the old one, the sap-roller is made gradually to describe an arc of a circle with its reverse end, about its pivot end as a centre, until it has described an arc of 90°. It is then advanced perpendicular to the old direction for a distance of 14′, (to allow for the thickness of parapet of the last zig-zag) after which its new pivot flank is made to revolve on the circumference of a circle whose radius is 14′, until the new direction is obtained.

In both cases, during the time the sap-roller is circling round, No. 1 obliques his trench slightly to the reverse flank, (Fig. 85) and as soon as he finds it necessary, on account of the enemy's fire, commences to place gabions on that flank, which then becomes the pivot flank. No. 2 keeps on the old reverse flank of No. 1, until the latter has advanced 5′ in the new direction, when he crosses his trench, and works on No. 1's new reverse flank. The other numbers act in the same manner.

215. **Widening Trench at Angles.**—After the change of direction is completed by all the numbers, the space between the gabions at the head of the first zig-zag and those of the new one will be barely 6′, whereas it must be 13′, allowing 18″ for the berm, but for no reverse slope. Four or five gabions of the first parapet, and those placed on the curve, must therefore be pulled down and emptied by the widening party, and set up in prolongation of the advanced zig-zag. (Fig. 85.)

216. **Cross-lifting a Sap-roller.**—A sap-roller is sometimes found to be too much to the right or left of its proper position, for covering the head of the sap. It must then be cross-lifted into its right place. A lever and fulcrum are required for this; a ponton balk will serve for the former, and a

sand-bag for the latter. The fulcrum is placed on the ground at the centre of the sap-roller, which is rolled forward a little; the lever is then placed so that the centre of the sap-roller, when rolled back, shall rest on it. The sap-roller is then pulled back and held securely by the sap-forks, while with the lever it is cut over to the right or left as may be required. This operation will probably have to be repeated two or three times, before the sap-roller is got into its right place.

217. **Joining two Single Saps.**—One method of joining two saps working towards each other is as follows: When the heads of the two saps are about 13′ apart, Nos. 1 do not advance, but all the numbers widen the trench to the full width of the sap, taking care not to throw the earth excavated in front of the end gabions of the saps. This done, the sap-rollers are cross-lifted and wheeled to the front. (Fig. 86.) When

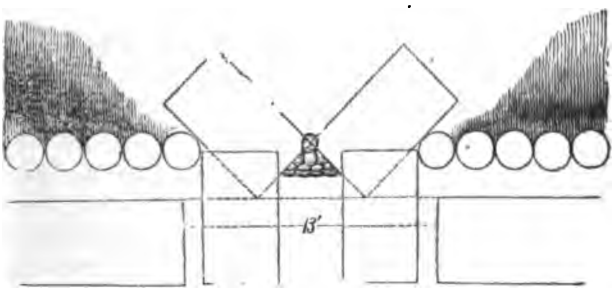


Fig. 86.—Joining Saps.

they are so far advanced that the sappers cannot easily move them, the saps are pushed on towards each other, sand-bags being used to cover the opening between the sap-rollers. Gabions are placed in the line of the parapet as the sap-rollers are advanced, and the trenches are joined. The sap-rollers are then in position if a double sap is to be driven from the point of junction of the two saps.

If a double sap is not to be commenced, and the sap-rollers

are to be saved, the method shown in Fig. 87 may be employed. The two saps are continued to within 10′ of each other, Nos. 2 and 3 working up to within 5′ of No. 1 in the left sap, which ought to be crowned with sand-bags, giving more

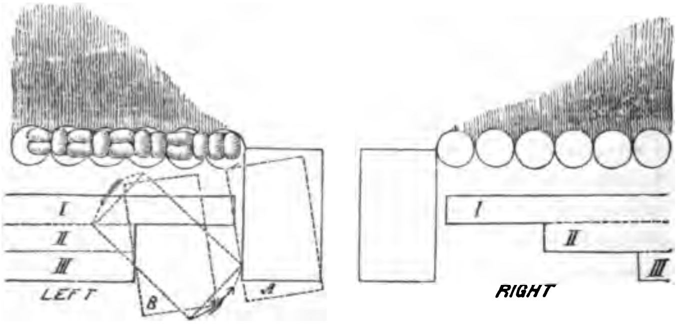


Fig. 87.—Joining Saps.

room and cover for the operation of cross-lifting. The sap-roller is then cross-lifted into the position A, and as soon as it is clear of the gabion at the head of the sap, it is rolled back to B, there wheeled on its centre as at C, and rolled clear of the sap. The men in the left sap now cease work. The men in the right sap work on until it meets the other, taking care to keep back the reverse end of their sap-roller, so that it may roll out in the direction AB, clear of the gabions at the head of the other sap.

The operation of joining saps finds its application in the advanced parallels, which are generally formed by single sap.

218. **Circular Place of Arms.**—A circular place of arms is formed by two single saps, which are broken out from the third parallel,* often one on each side of a re-entering angle, and about 40 yards from it; these two saps are pushed forward on a curve, and directed so as to meet each other about 25 or

* Conventional third parallel.

30 yards in front of the parallel. A circular place of arms is generally formed to commence a double sap from, and is of great use as a depot for the materials required in front, obviating the necessity of blocking up the third parallel.

219. **Anchor Fascines.**—On sloping ground it is advisable occasionally to use anchor fascines, to prevent gabions, especially those at the angles, falling into the trench. An anchor fascine should be about 2 or 3 feet long, having a loop of wire or rope about 6′ long fastened to its centre. It should be thrown over the parapet by No. 3, and the wire brought down between two gabions. When the hold of the fascine has been rendered firm by earth thrown on it, a picket 4′ long should be inserted in the loop, and the wire tightened up by twisting the picket, which is then placed across the top of the two gabions.

DOUBLE SAP.

220. **General Remarks on Double Sap.**—When the angles the zig-zags make with each other become less than 30°, that is when 100 yards of zig-zag do not carry the approaches more than 32 yards to the front, the advance is continued in a direct line on the fortress. This is done by means of the double sap, which has a parapet on both sides of the trench to cover it from the fire of the enemy's works on both flanks, and is also protected by traverses, placed on each side alternately at such intervals as may be necessary, to prevent it from being enfiladed from the works directly in its front.

The traverses should not be placed at less intervals than 9′ in the clear, if guns are to be passed up the sap; the intervals may be greater if the command of the works in front be small, but a trench with numerous traverses will always be safer than one with few, and does not take any longer to execute, though

of course it requires a larger expenditure of materials. The angle gabions may advantageously be anchored as described in par. 219.

221. **Position of First and Second Traverses.**—The traverses in the plates are shown at the minimum intervals of 12′ from gabion to gabion, and of the minimum thickness of 3 gabions, but these intervals and thicknesses may be varied according to circumstances. The first traverse of a double sap is always made about 6 gabions thick, (or nearly the thickness of the parapet, to avoid the useless removal of the earth) and is not revetted in front. The position of the first traverse depends on the direction from which guns are to be brought up; for instance, if the guns are to come from the parallel on the right, the first traverse should be on the left, so as to render the movement as easy as possible; if the guns are to be brought up from the parallel on the left, the first traverse should be made to the right. The second traverse should be at the minimum interval from the first, as it has to cover the whole of the communication through the parapet, and the parallel itself.

222. **Height of Traverses.**—The height of the traverses should be at least 7′ in all, the earth above the gabions being retained by sand-bags if possible; the objection to crowning parapets, and especially traverses, with fascines is that if a fascine be struck by a shot, it is apt to bring down with it several of the gabions on which it rests.

223. **General Remarks continued.**—Double saps are usually broken out from the middle of a circular place of arms. If two are driven parallel to one another on the same capital, they should be 16′ apart between the gabions.

There are two kinds of double sap; viz., the kneeling double sap, and the standing double sap.

224. **Brigades for Kneeling Double Sap.**—Three brigades, consisting of one non-commissioned officer and eight sappers each, are required for kneeling double sap. These brigades are respectively known as right, centre, and left.

225. **Preparations for Passing Sap-Rollers over Parapet.**—The head of a double sap is protected by a line of four sap-rollers, which may either be lashed together or moved independently. The central line of a double sap to be broken out having been fixed, and the position of the first traverse determined, (assumed here to be on the right, [Fig. 91]), all preparations are made by day, to commence work at dusk.

The sap-rollers having been brought along to the required position, are placed in line on the ground in rear of the parallel, touching each other. A wooden cross, of 2″ stuff, with arms 2′ 6″ long, is placed in the extreme ends of the two outside sap-rollers, and securely wedged there. Four 30′ spars are then inserted in the four sap-rollers, passing through the angular openings in the crosses, and wedged up as tightly as possible against the inside of the sap-roller. (Fig. 88.) Each spar is kept in position by a rope secured to one end, passed over the first sap-roller, round the spar between the first and second sap-rollers, over the second, and so on, and made fast to the other end of the spar; 300 feet of 2″ rope are required. Eight beams are now placed at intervals of 3′ 6″, reaching from the reverse side of the parallel to the top of the parapet, as A B (Figs. 89 and 90); for a parallel of full width, they must be 24′ long, and 6″ in diameter. Two pickets are driven into the ground at each end of the sap-rollers, round which two ropes are made fast, and passed *under* the cylinders and *over* them back again, to act as preventer ropes in lowering the sap-rollers on the other side of the parapet.

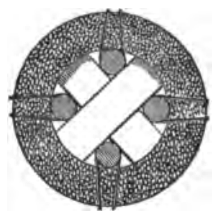


Fig. 88.

Planks may be advantageously laid across from the reverse slope to the berm, for the men to stand on during the operation of pushing the sap-rollers over. Any planks about 15′ long, such as platform sleepers, will do, and should be laid between all the beams, nine being thus required.

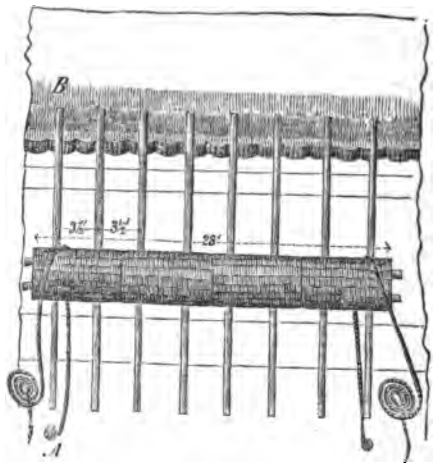


Fig. 89.—Passing Four Sap-Rollers Lashed together over a Parapet.

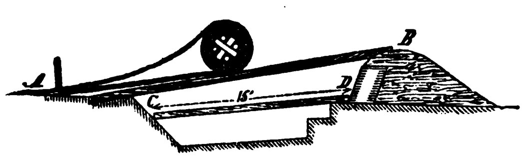


Fig. 90.—Section on A B, Fig. 89.

226. Passing the Sap-Rollers over the Parapet, Lashed together.—Everything being in readiness, the working party for the sap, consisting of 18 or 24 men, mount the reverse slope, and gradually roll the sap-rollers up, using their

hands in preference to sap-forks, when the platform is provided, but sap-forks, if they have to work from the bottom of the trench. On no account should sap-forks and hands be used together, as in the dark the sap-forks will be liable to injure the men's hands. Eighteen men should push over the sap-rollers in about 5 minutes.

The disadvantage of this method is that it requires a quantity of stores, which may not always be available; also since the parapet cannot be cut away, the numbers working through it will take more time to effect a communication with the Nos. 1 in front. On the other hand, the men are less exposed to fire, as the sap-rollers are in position for the sap without being cross-lifted, and being lashed together cannot separate when moved forwards as the sap advances.

If it be known previously that from a certain point in a parallel a double sap will have to be broken out, it is advisable that the tasks of the first, or first and second reliefs, only should be executed at that part, so that the width of the parallel may be less, and shorter beams be required to span it.

227. **Passing Sap-Rollers over Parapet separately.**—If the rollers are to be passed over separately, the six gabions on the left of the central gabion are removed during daylight, and the ramp commenced. (Par. 192.) When it is dusk, the ramp is completed, the sap-rollers are passed over as quickly as possible, and placed in position 4′ from the base of the parapet.

228. **Breaking Out a Double Sap.**—Nos. 1 of the right and left brigades each place between the base of the parapet and the outer sap-rollers, two gabions, their centres in line with the ends of the sap-rollers; the distance between the two rows of gabions is therefore 26′. They then fill these gabions with half-filled sand-bags, and build up the interval between the gabions and the parapet with sand-bags, and construct the sand-bag parapet, &c., as described in par. 201. Nos. 1 then

excavate a trench 4′ long parallel to the gabions just placed, 18″ wide, and 18″ deep. Nos. 1, right and left, leave a berm 18″ wide between their trenches and the gabions, and No. 1 centre makes his trench 6′ from that of No. 1 right or left (in

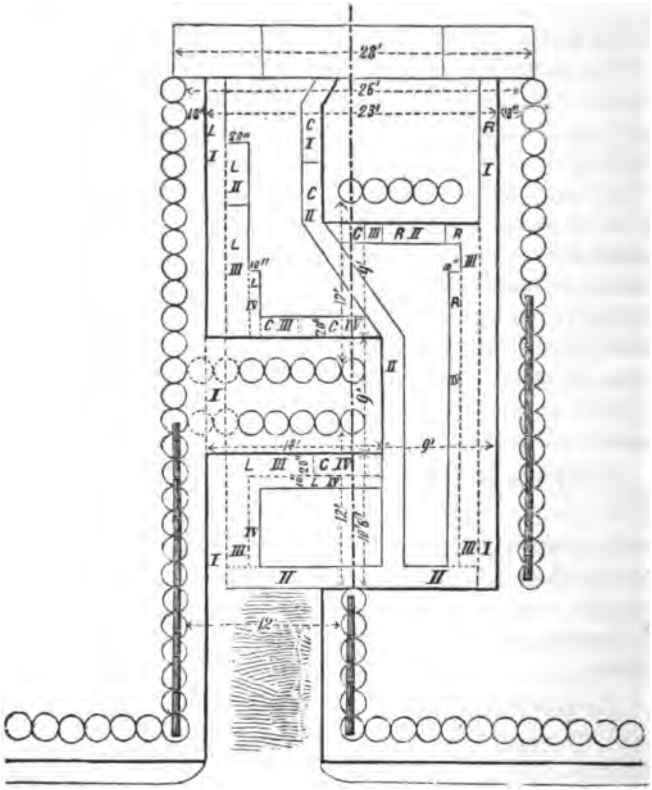


Fig. 91 —Kneeling Double Sap.

this case No. 1 right, Fig. 91) so that he may be in the required position to clear the end of the second traverse.

Nos. 2 at once commence a trench 18″ wide and 3′ deep

immediately at the foot of the slope of the parapet of the parallel, the length of which will be 6′ on one side of No. 1 centre, and 12′ 6″ on the other side. The Nos. 2 must follow their Nos. 1, as described in par. 230, as soon as the latter have advanced 5′ from this trench, which should be completed by that time; if it is not completed, that must be done by Nos. 3. The earth from this trench must be thrown upon the parapet of the parallel, avoiding as much as possible that part which is to be cut away for the communication with the parallel.

No. 3 left (in this case) works through the parapet in rear of his No. 1, making a trench 18″ wide and 18″ deep below the ground line; this trench is afterwards deepened to 3′ by No. 3 centre, who follows 5′ in rear of No. 3 left. Nos. 3 go over when required to assist in moving forward the sap-rollers, and follow their Nos. 2 as soon as possible, as described in par. 230.

The other half brigades clear the earth out of the parallel, and revet the communication through the parapet of the parallel as soon as it is made, leaving the widening of it to be executed by the infantry working party that comes on duty with the next relief.

229. **Duties of Men in Kneeling Double Sap—Non-Commissioned Officers.**—The sappers in the kneeling double sap have, in a general way, the same duties to perform as in kneeling single sap.

The senior non-commissioned officer is responsible for the whole sap, but is in special charge of the centre brigade. He pays particular attention to the direction in which No. 1 centre works, so that he may clear the ends of the traverses; he also gives the word when the sap-rollers are to be moved forward, and therefore Nos. 1, right and left, inform him when they are ready for another gabion. His commands are—*Gabions. Together Forward. Halt. Pull back the Sap-rollers. Secure the Sap-rollers.* The two other non-commissioned officers re-

spectively take charge of the right and left brigades, and are held responsible for their direction, and that the gabions are placed in the correct line, and at the proper slope. They must see that the communication through a traverse is never closed, until that round it is open, and that each man works as near the head of the sap as possible, work in front of a traverse being more important than that in rear.

230. **Duties of Left Brigade.**—No. 1 left saps straight to his front, excavating a trench 18″ wide and 18″ deep, leaving a berm 18″ wide.

No. 2 left follows his No. 1 as soon as he has advanced 5′, widening his trench 20″ until he arrives at the berm of the second traverse, when he works to his right, along the rear of the traverse, placing five of its rear gabions, and leaving room for the first two gabions, which are not to be placed until a passage has been formed round the traverse. As soon as his No. 1 has advanced beyond the traverse sufficiently he will follow him.

No. 3 left follows his No. 2 deepening his work 18″.

No. 4 left widens the trench finished by No. 3 10″, fills up the openings left by No. 1 through the traverse with sods, stones, etc., and places the two other gabions in front and rear, as soon as the communication round the traverse is complete.

231. **Duties of Centre Brigades.**—No. 1 centre excavates a trench 18″ wide and 18″ deep, moving straight forward, until he gets to the front corner of the second traverse, when he obliques to his left, so as to clear the rear corner of the next traverse.* He must not throw his earth on to the positions of the traverses, or on to the ground to be excavated by the other sappers.

No. 2 centre follows his No. 1, deepening his trench 18″.

No. 3 centre saps out of the trench formed by his No. 2 in

* With traverses 9′ apart the angle is 36°, corresponding to the angle made with the horizon by a slope of $\frac{3}{4}$.

rear of the second traverse, until he meets No. 2 left or right (in this case left). He then moves forward and connects the centre and left or right saps (in this case left) by a trench in front of the traverse, placing the gabions as he proceeds. His trench is always 20″ wide and 18″ deep.

No. 4 centre follows his No. 3, deepening his work 18″; he builds up between the two end gabions of the traverse with sods or sand-bags.

232. **Duties of Right Brigade.**—The right brigade sappers work in the same way as in kneeling single sap, until they arrive at the position of the third traverse, which is formed by them in exactly the same manner as the second traverse by the left brigade.

233. **Moving Forward Sap-Rollers.**—When the sap-rollers have to be moved forward, the sappers of the right and left brigades act as in single sap; and the four sappers of the centre brigade will move forward the two centre sap-rollers. In sapping up a steep slope, it will be necessary, when moving forward the sap-rollers, to obtain the assistance of some of the demi-brigades resting.

234. **Rate and Materials.**—Kneeling double sap advances at the rate of from 5 to 10 feet per hour, and requires per relief of 8 hours from 40 to 80 gabions, and from 14 to 28 6′ fascines, in addition to 14 gabions and 5 6′ fascines, or 34 sand-bags for each traverse.

235. **Tools.**—The tools required will be 24 picks, 24 shovels, 9 pairs knee-caps, 8 long sap-forks, 4 short sap-forks, 3 6′ measuring rods, 3 20″ gauges, 7 18″ gauges, and 2 10″ gauges.

236. **Standing Double Sap—Number Brigades Required.**—Three brigades, of one non-commissioned officer and

six sappers each, are required for standing double sap. These brigades are respectively known as right, centre, and left.

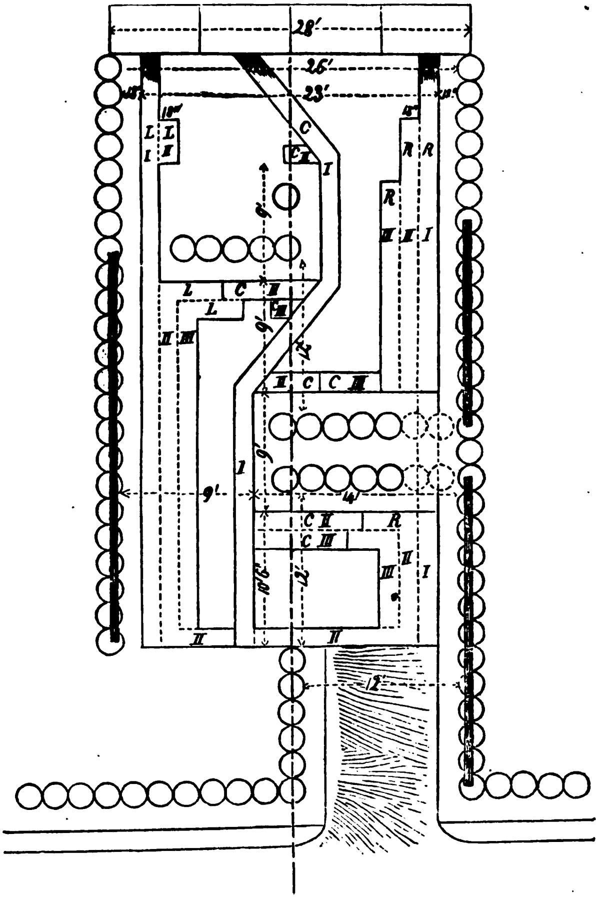


Fig. 92.—Standing Double Sap.

237. **Breaking out Standing Double Sap.**—The mode of breaking out from a parallel is the same as in kneeling

double sap, except that Nos. 1 excavate their trenches to a depth of 3′.

238. **Duties of Right Brigade—Standing Double Sap.** —Figure 92 illustrates the progress of a standing double sap, with the first traverse on the left.

The duties of the non-commissioned officers are the same in the standing as in the kneeling double sap.

No. 1 right continues sapping from the trench he has previously made, leaving a berm 18″ wide, working straight to his front, exactly as in the kneeling double sap, but excavating a trench 18″ wide and 3′ deep.

No. 2 right follows his No. 1, as soon as the latter has advanced 5′ to the front, widening his trench 18″. On reaching the position of the berm of the second traverse, he saps to his left, placing five of its rear gabions, until he meets No. 2 centre, when he again follows his No. 1 in front of the 2d traverse, until he comes to the fourth traverse; he then again saps to his left, and so on.

No. 3 right widens the trench of his No. 2 18″. When the communication round the traverse is completed, he fills up his No. 1's trench through the traverse (the bottom part with stones or fascines to assist drainage), and completes that part of the traverse.

239. **Duties of Centre Brigade—Standing Double Sap.** —No. 1 centre excavates a trench 18″ wide and 3′ deep, moving straight to his front, until he gets to the front corner of the second traverse, when he obliques to his right, so as to clear the rear corner of the next traverse, and so on.

No. 2 centre breaks out to the right of the trench of his No. 1 (as soon as the latter has got far enough ahead), and saps along the rear of the second traverse until he meets No. 2 right. He then passes round to the front of the traverse, and saps along it until his No. 1 has got far enough ahead for him to

commence sapping in rear of the third traverse, and so on. His trench is always 18″ wide and 3′ deep.

No. 3 centre widens the trench of his No. 2 18″, until he meets No. 3 right; he then passes on to the front of the traverse, and continues the trench commenced by his No. 2, until he reaches that of No. 3 right. He builds up between the two end gabions of the traverse, with sods or sand-bags.

240. **Duties of Left Brigade—Standing Double Sap.**—The left brigade work in the same manner as in the standing single sap, until they arrive at the position of the third traverse, which is formed by them in exactly the same manner as the second traverse by the right brigade.

241. **Moving forward Sap-Rollers—Standing Double Sap.**—When the sap-rollers have to be moved forward, the sappers in the right and left brigade act as in single sap, and the centre brigade, assisted by some of its spare numbers, move forward the two centre sap-rollers.

242. **Rate and Materials—Standing Double Sap.**—Standing double sap advances at the rate of from 3½ to 7 feet per hour, and requires per relief of 8 hours, from 28 to 56 gabions, and from 5 to 10 6′ fascines, in addition to 14 gabions, and 5 6′ fascines, or 34 sand-bags, per traverse.

243. **Tools for Standing Double Sap.**—The tools required are 18 picks, 18 shovels, 8 long sap-forks, 4 short sap-forks, 3 6′ measuring rods, and 9 18″ gauges.

244. **Finishing Double Sap.**—When a double sap has advanced sufficiently, that is at the commencement of the second relief, the tongues of earth are removed in one relief by infantry, arranged at intervals of 6′ along the crest of each parapet. Slopes are formed at the sides of the trench by cutting away 6″ of the berms, and drains are made. If there be

a deficiency of earth for the parapet at any traverse, the trench of the sap in front of the traverse must be deepened. The infantry should be superintended by sappers, in the usual proportion of 1 sapper to 25 infantry.

HALF DOUBLE SAP.

245. **Half Double Sap.**—Lodgements on the crest of the glacis are formed by half double sap, the trench being protected from enfilade fire, and also from the reverse fire of the collateral works of the place, by traverses; those that are joined to the parapet are called attached traverses, and those that are on the reverse, not being joined to the parapet, are called detached traverses.

There are two methods of executing half double sap, by the kneeling and by the standing saps, each requiring three brigades of sappers of the usual strength. These brigades are called A, B, and C brigades respectively.

246. **Duties of A Brigade.**—The senior non-commissioned officer is in charge of A brigade, and is responsible for the whole work. The sappers of A brigade, except No. 4, whose duties are described below, sap along, parallel to and about 18 feet from the crest of the glacis, in the usual manner. The sap-head is covered by two sap-rollers, the one on the reverse flank being close in rear of the other, and overlapping it a foot. (Fig. 93.) If necessary, owing to great obliquity of the fire, the reverse of the trench may be further protected by a sand-bag parapet.

No. 4 proceeds as usual until he reaches the position of the attached traverse, (marked W in Figs. 93 and 94). The first attached is usually commenced about 20′ from the shoulder. As soon as No. 3 A has advanced clear of W, No. 4 A, and the rear numbers of his own brigade get up one or two sap-rollers,

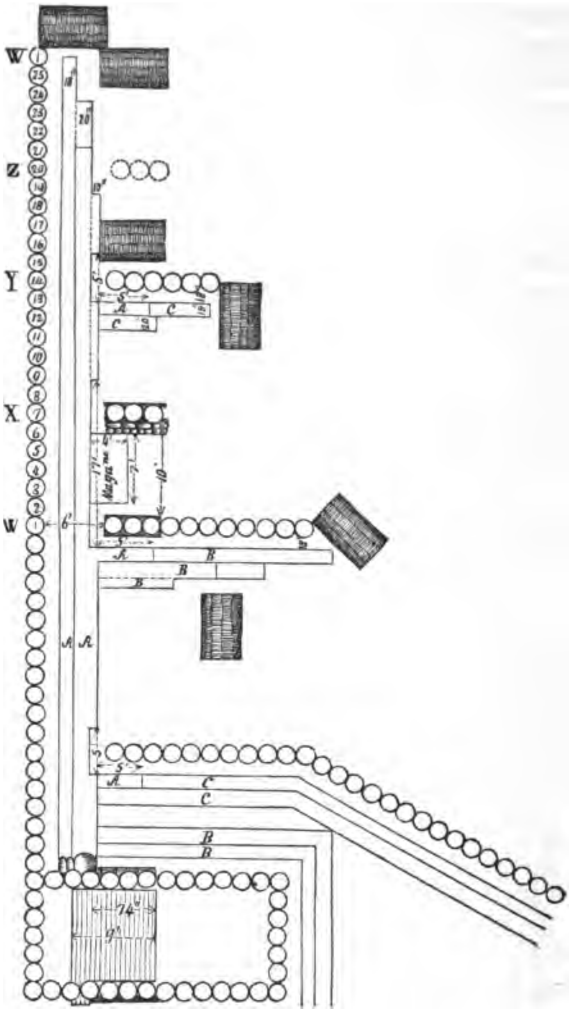


Fig. 93.—Half Double Sap.

which will be afterwards passed on to the front, and will be used by C brigade for forming the detached traverse. He then places on the reverse of the sap, and perpendicular to it, two 6′ fascines in a line with the gabion W, the ends being 6′ from it, and upon these fascines three gabions, the first being 6′ from the gabion W. He then saps for a distance of 5′ along in rear of the gabions, making his trench 18″ wide and 18″ deep, leaving a berm 18″ wide, and forming a cover from which B brigade commences its work.

He next places in a similar manner two fascines and three gabions opposite the gabion X (the 7th counting W) for the front of the first attached traverse, filling them with sand-bags, and building up a sand-bag parapet behind them. He should commence this work as soon as his No. 3 is far enough ahead, and should fill the gabions farthest from the parapet first. No. 4 A then follows his No. 3, widening his trench as usual 10″, until he reaches the position of the first detached traverse, or the fourteenth gabion, marked Y. He then places three gabions, the first being 6′ from Y, and saps along in rear of them, making a trench 18″ wide and 18″ deep, from which C brigade will commence work. These gabions may be filled with sand-bags, as they have afterwards to be removed; fascines are not to be placed under them. No. 4 A then follows his No. 3, widening his trench as usual 10″, until he reaches the position of the second attached traverse, 50′ or 25 gabions from W, when he commences that traverse in the same way as he did the first attached traverse, and thus the sap proceeds.

If the fire from the next salient takes the sap very much in reverse, No. 4 A will make opposite to Z, the 20th gabion, a temporary traverse of three or four gabions filled with sand-bags, having a parapet of sand-bags behind them, or one of the spare sap-rollers may answer the purpose. In addition to the above duties, No. 4 A assists to move forward the sap-rollers.

247. **Duties of B Brigade.**—The sappers of the B brigade form the attached traverses, and are distributed as follows. No. 1 B continues the sap commenced by No. 4 A, opposite W, until he has placed the number of gabions necessary for the rear of the attached traverse. The length of the attached traverses will depend upon what length of approach they have to defilade. One that has to cover a portion which is to be converted into a battery, or from which a great gallery of descent is to be driven, should be 14 or 15 gabions long, though 10 gabions would be sufficient if it were simply required to cover the trench when widened out. As a general rule, the traverses in front must be longer than those in the rear, as the fire then takes the trench more in reverse.

When No. 1 B has placed the gabions required for the rear of the traverse, he changes his direction, commencing to turn his sap-roller after having placed the last gabion but one, and under cover of one or two sap-rollers completes the end of the traverse. He then goes round and completes the front of the traverse by sapping on from X, being protected by the sap from Y, pushed by C brigade. The other Nos. follow No. 1, and have the same duties as in ordinary kneeling sap. When the passage round the traverse is complete, they fill up the opening formed by A brigade through the traverses, unless a magazine is to be formed in it. The B brigade must be careful not to throw their earth on the ground which is to be excavated for the magazine.

248. **Duties of C Brigade.**—The detached traverses are formed by C brigade. As soon as No. 4 A is clear of the Y trench, No. 1 C takes his place, and saps along perpendicularly to the crest, until he reaches the prolongation of the end of the attached traverse; he then curves round on a circle of 9′ radius, until the direction is perpendicular to the line of fire; he then continues straight ahead until his parapet defilades the whole of the passage round the attached traverse. The

other Nos. follow him in the same manner as in ordinary kneeling sap.

249. **Standing Half Double Sap.**—Half double sap can be executed by standing sap, the only difference being that No. 3 A performs the duties specified for No. 4 A in kneeling half double sap.

250. **Magazine in Traverse of Lodgement.**—When a magazine has to be made in a traverse, a party of one non-commissioned officer and six sappers commence work at it, as soon as No. 4 A has placed three gabions opposite to X. Two of them start from No. 3 A's trench and commence the excavation for the magazine, 7′ wide, and 7′ 4″ long, towards the end of the traverse, excavating only to a depth of 3′. They at first throw their earth towards the crest of the parapet, but afterwards they may throw it to their front, taking care that it is not deposited where it will have to be removed. A third man makes the entrance by widening out No. 3 A's trench to 3′, and by deepening it to 3′ 9″; he also, with the assistance of the spare numbers, deepens the body of the magazine to the same level.

The whole party then place the frames in the body of the magazine, and arrange the splinter-proofs on them. The entrance frames and splinter-proofs must not be placed until the communication round the traverse is completed, when the front opening may be filled up; this can best be done by placing a gabion in No. 3 A's trench, building up the step with sand-bags, placing two 6′ fascines across the top, and three gabions above them. The revetment over the entrance is completed with three gabions, resting on the splinter-proofs. When completed the lower portion of the entrance should be filled up with sand-bags, to reduce the size of the doorway and to prevent water coming in.

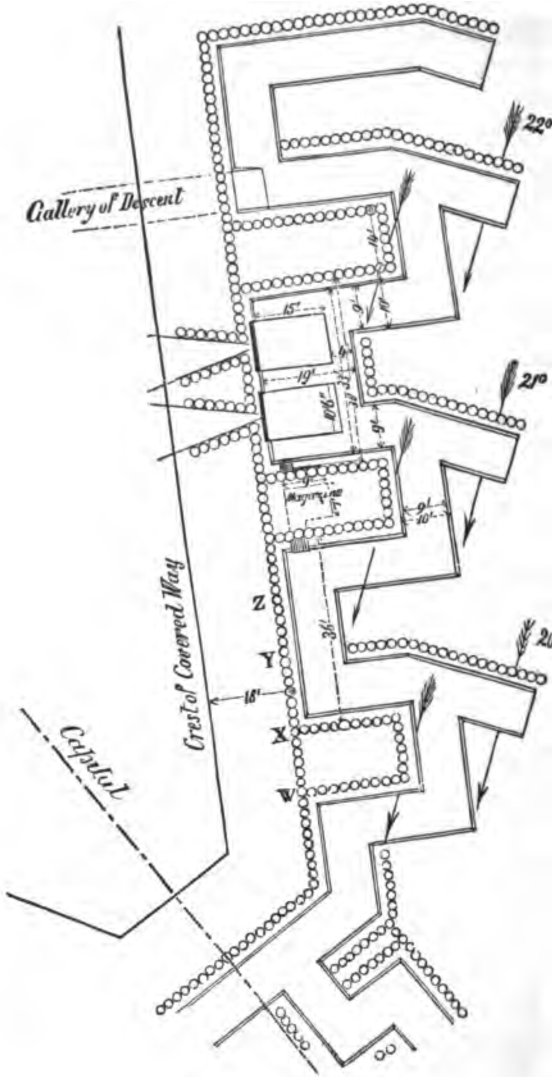


Fig. 94.—Half Double Sap.

251. **Widening out Half Double Sap.**—The widening of the lodgement will be made by infantry, arranged at intervals of 5′.

252. **Height of Traverses.**—The traverses must be made high enough to defilade the trenches.

253. **Portions for Batteries.**—In those portions that have to be converted into batteries, the rear of the trench must be protected by a parapet formed by two sappers, sapping back from the trench made by B brigade, into that formed by C brigade; they will place their gabions 22′ from the crest. (Fig. 94.) Care should be taken that the ground on which the platforms are to be laid is not cut away more than necessary.

The embrasures will be sapped out as described in par. 320.

254. **Rate of Advance.**—Kneeling half double sap advances at a rather slower rate than kneeling single sap.

255. **Tools and Material for Half Double Sap.**—Supposing the kneeling sap to be employed, and that each relief completes a length of 50′, or one traverse, the tools and material required will be 24 picks, 24 shovels, 9 pairs knee-caps, 10 long sap-forks, 3 short sap-forks, 3 6′ measuring rods, 12 gauges, 5 sap-rollers, 82 gabions, 25 6′ fascines, 292 sandbags.

256. **Material for Magazine.**—For a magazine there will be required 7 frames 2′ 11″ × 3′ 9″, 12 splinter-proofs 10′ × 9″ × 6″, 6 splinter-proofs 13′ 6″ × 9″ × 6″, and 160 running feet of plank 10″ × ¾″.

HALF SINGLE SAP.

257. **Description.**—When the sappers have only to fear fire coming from the flank, in a direction nearly perpendicular to that of the sap, they may work without the sap-roller. In

this case No. 1 is covered by the gabions already filled, while he is placing and filling a new one. This species of sap is called the half single sap, and is occasionally employed.

SECTION XI.—SIEGE BATTERIES.

GENERAL DESCRIPTION—REVETMENTS—ELEVATED BATTERIES—HALF-SUNKEN BATTERIES—SUNKEN BATTERIES—INDENTED BATTERIES—HOWITZER BATTERIES—MORTAR BATTERIES—BREACHING AND COUNTER BATTERIES—PLATFORMS—POWDER MAGAZINES—REMARKS.

GENERAL DESCRIPTION OF SIEGE BATTERIES.

258. In military engineering the term battery signifies the emplacement of artillery destined to act offensively or defensively.

Different Kinds of Batteries.—Siege batteries are described

1*st.* According to their construction, as elevated, sunken, or half-sunken batteries. Batteries are termed elevated when their terre-pleins are formed by the natural surface of the ground. They are half-sunken when the terre-plein is lowered 2′, and sunken when it is lowered 3′.

2*d.* According to the character of the artillery they are to contain, as gun, howitzer, or mortar batteries.

3*d.* According to their object, as enfilading, counter, or breach batteries.

Batteries are ordinarily made with their parapets perpendicular to their line of fire, but occasionally where a narrow ridge or dyke presents a favorable site for their construction, it is necessary to have the general direction of the parapet inclined at an angle to the line of fire; and as the parapet in each gun-portion must always be perpendicular to the line of fire, it becomes necessary to indent the parapet.

Batteries so constructed are called indented batteries.

259. **Definitions of Parts of Batteries, Profile.**—The profile of a battery is a vertical section through the parapet taken perpendicularly to the line of its general direction. In the interior of the battery, the floor, or surface of the ground, is called the terreplein. Figure 95 represents the profile of an

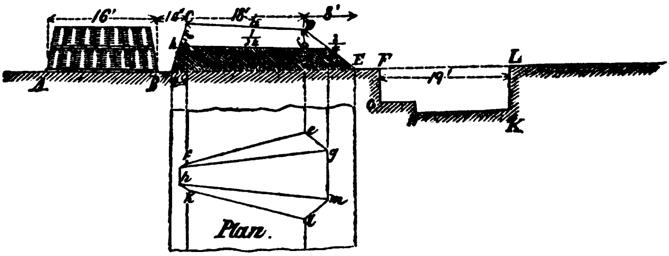


Fig. 95.—Embrasure and Traverse.

elevated battery, where A L is the level of the ground or ground line, A B the terreplein of the battery, B C the interior slope, C D the superior slope, D E the exterior slope, E F the berm, F G H K L the ditch, and B C D E the parapet. The intersection of the interior and superior slopes at C is the interior crest, and the intersection at D of the superior and exterior slopes the exterior crest. C D measured horizontally is the thickness of the parapet, B E is the base of the parapet. In any work with a ditch, the side of the ditch nearest the parapet is called the scarp and the side furthest away the counterscarp.

260. **Embrasures.**—Embrasures are openings in the parapet through which the pieces may be fired. The lower surface is termed the sole, the sides the cheeks, and the interior opening the throat of the embrasure. In Fig. 95 *e g h f* and *m h k l* are the cheeks; *h g m* the sole; *f h k* the throat; the intersection *h* of the sole with the interior slope, the sill; and *e g m l* the mouth. The widening of the embrasure towards the mouth is called the splay, and the portion of the interior slope of the parapet, between the sill and the terreplein, is called the genouillère.

261. **Merlon.**—A merlon is the portion of the parapet between two embrasures.

262. **Slopes.**—Slopes are usually described by fractions in which the numerator expresses the height, and the denominator the base of the slope. Thus a slope described as $\frac{2}{1}$ (or verbally two on one) is one in which the vertical height is twice the base; while that expressed by $\frac{1}{2}$ (or verbally one on two) is one in which the base is double the vertical height.

263. **Traverses.**—A traverse is a mound of earth, usually revetted, with its longer sides perpendicular to the parapet. Its object may be to prevent the whole length of parapet from being enfiladed, in which case it is made thick enough to resist direct fire, and is called a bomb-proof traverse; or merely to limit the effect of the explosion of shells, in which case it is about 6′ thick, and is called a splinter-proof traverse. The latter is of more general application in siege batteries. Splinter-proof traverses may be attached or detached from the parapet; they should be made at least 16′ long, so as to cover the rear of the gun-platforms, and if possible there should be one between every two adjacent guns.

264. **Epaulment.**—An epaulment is a mound of earth, thrown up at the end of a battery at right angles, or nearly so, to the direction of the parapet, to protect the battery from

oblique fire. Its parapet has the same height as that of the battery, but less thickness, and it is usually unrevetted. The end is finished off with a slope of $\frac{1}{1}$.*

If the flank of a battery does not require any epaulment, the parapet must be lengthened about $3\frac{1}{2}'$ at the interior crest, in order to make it as solid as the outer flank. This extra piece, called an extreme half merlon, is made from 8′ to 11′ long at its base, according as the battery is half-sunken or elevated.

265. **Profiles of Batteries, Height and Thickness of Parapet.**—The interior height of the parapet should not be less than 7′ 6″, to give sufficient cover to men standing at the rear of the platforms, making allowance for the parapet becoming damaged. The thickness of the parapet depends on the nature of projectile which may be fired at it. Against all siege guns, including the 30 pounder rifle, and smooth-bored guns up to the 10 inch, 18′ is sufficient, but against heavier guns than the above, it should be increased to 25, or even 30, feet when it is to be subjected to long continued firing.

266. **Inclination of Superior Slope.**—The inclination of the superior slope should be as little as possible in order not to weaken the parapet more than necessary. When the object has been merely to carry rain water off to the front, a slope of $\frac{1}{12}$ has been usually given.

* The parapet of a battery is called in the artillery arm of the service the epaulment. There is good military authority for this use of the term. The authorities however are divided, and those followed by the engineers give as the true meaning of the word epaulment, *any covering mass not arranged for defensive fire.* Thus a traverse, a parados, the cover of approaches, &c., might properly be called epaulments, while any covering mass arranged with a banquette or with embrasures should be called a parapet. The epaulment does not provide any view of the ground in front, while the parapet does.

267. **Interior and Exterior Slopes.**—The height of the exterior crest depends on that of the interior crest, on the thickness of the parapet, and the inclination of the superior slope. The interior slope should be made as steep as it will stand, in order to obtain good cover for the men, and to enable the guns to be run up as close as possible; it has a slope usually of $\frac{4}{1}$. The exterior slope of a battery is usually $\frac{3}{4}$.

268. **Interior Slope, &c., Mortar Batteries.**—Mortar batteries require the same thickness of parapet as gun batteries, but as mortars are fired at great angles of elevation, the interior slope is not revetted.

269. **Berm and Ditch.**—A berm is necessary in a battery having a ditch in front, to prevent the weight of the parapet forcing in the scarp of the ditch; it should be of such width that if destroyed the earth will take its natural slope from the base of the exterior slope to the bottom of the ditch, without bringing down any portion of the parapet. In a siege battery the ditch is never considered a means of defence, and its depth and width are regulated simply by the convenience of obtaining the earth necessary for the parapet with the least amount of labor. Interior berms are required when the terreplein of a battery is excavated.

270. **Position of First Batteries in a Siege.**—The first batteries in a siege are usually situated about thirty yards in advance of the parallels. The nature of the ground, or danger from sorties, may render it necessary to place them behind or in the parallel. Whatever their position may be, it is essential that they should be connected with the parallel by well-covered and commodious communications, and when in the parallel a trench should be cut in their rear, so that the working parties and guards of the trenches may pass around and not make a thoroughfare of them.

REVETMENTS OF BATTERIES.

271. **Materials Used for Revetments.**—The materials generally used for revetments in siege batteries are gabions, fascines, and occasionally, sods, logs, hurdles, casks, wood planking, marsh sods, &c.

272. **Gabion Revetment.**—As a rule the best revetment is that made of gabions and fascines, as shown in Figs. 96 and 97. The interior slope is commenced by placing a course of fascines on the ground along its base, a trench five inches deep being cut for its reception. The fascines are fastened down with three pickets, one driven through the middle and one 18″ from each end of every fascine. The earth of the parapet is thrown in up to the top of this course and rammed. The first course of gabions is placed with the points of the pickets up, resting on the fascines just laid and the solid ground, which has been previously prepared so as to give the gabions the proper slope of $\frac{4}{1}$. Earth is thrown into and in front of the gabions and well rammed. When the gabions are full, a second course of fascines is laid on their inner edges, and driven down with a maul until it is firmly engaged on the points of the pickets. The second course of gabions is placed so that the axis of each gabion coincides with that of one of the lower course. The points of the pickets are down, and driven into the fascines. The throats of the embrasures are formed by omitting a gabion and sawing out the corresponding portion of the upper course of fascines. The parapet is then completed, the small extra height being made up with sods, sand-bags, or well rammed earth; fascines should never be used on the top, as the effect of a shot striking them would be to carry away a whole length of 18′ and a portion of the parapet to which they are picketed.

273. **Means of Increasing Stability.**—The stability of a parapet may be much increased by the employment of anchor fascines or logs of wood, buried in the parapet about four feet

from the gabions, with which they are connected by rope or wire passed through the web, or between the gabions, and held there by a picket. (Fig. 96.) Frequently every second gabion

Elevation. Section.
Fig. 96.—Revetment with Gabions.

is anchored to a picket, driven 3′ in front of it in the parapet. (Fig. 97.)

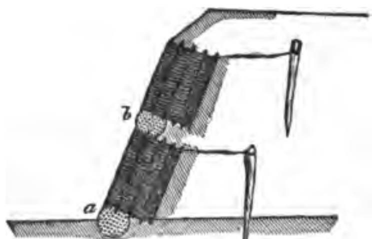


Fig. 97.—Revetment with Gabions.

274. **Gabions not a Good Revetment in Sand.**—Gabions alone do not make a good revetment for batteries when the soil is very dry and sandy, as the shock of the guns shakes the sand out through the interstices in the web. This may be corrected by filling those most exposed to these shocks, with sand-bags or sods.

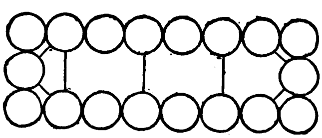


Fig. 98.—Plan of a Traverse.

275. **Splinter Proof Traverses with Gabions.**—A course of fascines is employed to form the base of the revetment, as in the previous case. The arrangement of the first

course of gabions in a detached traverse is shown in Figure 98. When nearly filled, the opposite rows should be tied together

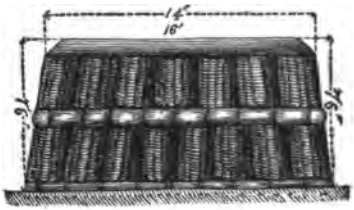


Fig. 99.—TRAVERSE.

and across the corners with wire or rope; when filled they are crowned with fascines. In the second course there is one less gabion on each side than in the first. (Fig. 99.) The two rows meet at top, where they are tied together. (Fig. 100.) The earth is rounded over the top to the depth of 18″.

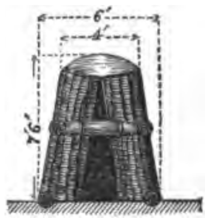


Fig. 100.—TRAVERSE.

Splinter-proof traverses in an elevated battery are generally detached, as thus they enable men to obtain cover more readily, if a shell falls into the battery.

276. **Embrasures with Gabions.**—The sole of the embrasure is an inclined plane, falling about 1′ to the exterior. In siege batteries, embrasures are made with less splay than in defensive batteries, as the guns are not required to have so much lateral range. The usual way to lay them out, is to stretch a line along the line of fire, measuring 1′ on each side of it at the throat of the embrasure, and at 5′ further to the front, measuring 1′ 6″ on both sides, perpendicular to it. These points at 1′ and 1′ 6″ give a splay of $\frac{1}{10}$, and lines drawn through them and continued to the exterior slope mark the bases of the cheeks of the embrasure. (Figs. 101 and 102.) Along these lines trenches 5″ deep are ex-

cavated and fascines 14′ long are laid in them. The revetment of each cheek is formed as follows: Commencing at the throat, seven gabions are placed in a line, and resting on the fascine just laid. The first gabion is vertical; the last has an inclina-

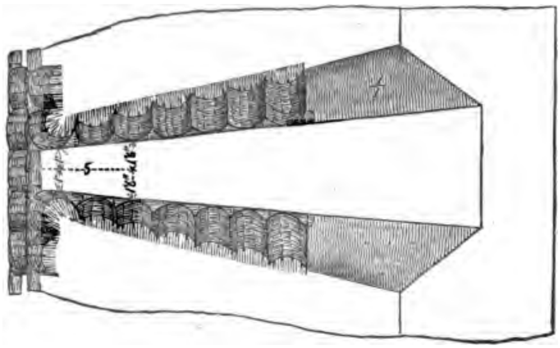


Fig. 101.—Plan.

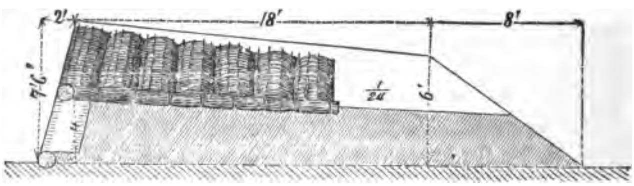


Fig. 102.—Sec'ion.
EMBRASURE REVETTED WITH GABIONS.

tion of $\frac{3}{1}$. In these positions the extreme gabions are filled and secured, and the intermediate gabions are aligned on them at top and bottom. All the gabions are securely anchored to pickets driven 3′ within the merlon. The strongest gabions should be selected for this part of the revetment. Although it is essential that the embrasure gabions should be well anchored, they should never be tied to each other. The independence of the parts in this revetment is one of its valuable qualities, as one portion may be torn away by a shot without endangering the adjacent parts.

Fourteen gabions and $2\frac{1}{2}$ fascines will revet 100 superficial feet.

277. **Fascine Revetment.**—A durable revetment may be formed of a wall of fascines, with occasional 6′ fascines as headers (or perpendicular to the face) the whole being firmly picketed to the parapet. (Figs. 103 and 104.) Care must be

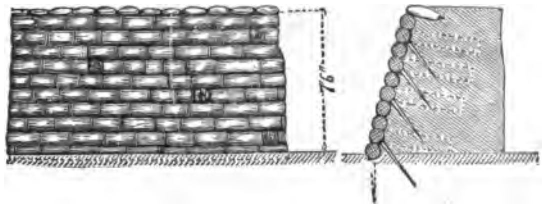


Fig. 103. Fig. 104.
Revetment with Fascines in Loose Soil.

taken that the fascines break joints. In stiff soil the headers may be dispensed with, each fascine being secured by several pickets.

The line of the foot of the interior slope is levelled and a trench 5″ deep is excavated to receive the first course of fascines. The fascines are then laid, aligned, and fastened down with three pickets, one driven through the middle and one 18″ from each end of every fascine. The earth of the parapet is levelled up to the top of this course and rammed. The second course is laid, breaking joints with the first and picketed, the stakes passing through both courses. The other courses are laid in the same way, the earth always being brought up to the level of the top of each course before another is laid.

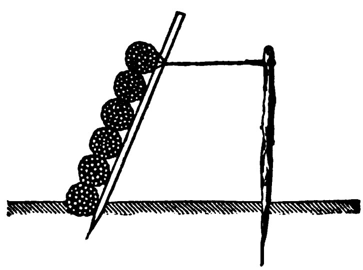


Fig. 105.

In order to give uniformity to the slope of the revetment, it will be convenient to drive guide-stakes having the proper inclination in front of the first course, as soon as it is laid. (Fig. 105.) The withes of the fascines should have their knots towards the parapet.

The fifth course brings the revetment to the height of the sole of the embrasure. These fascines must be anchored; this is effected by making one end of a piece of wire, rope, or withe, fast to the fascine, and with the other taking two or three turns around a stake driven vertically into the parapet and three or four feet from the revetment. Each fascine of this course should have at least two anchoring pickets.

278. **Embrasures with Fascines.**—The sole is laid out and one course of fascines laid, as in the gabion revetment. The three remaining courses, which are required to finish this revetment, are laid so that the cheeks shall be vertical at the throat, and have a slope of $\frac{3}{1}$ at the exterior. Each fascine should be anchored twice, the anchoring pickets being driven 3′ within the merlon. The fascines must not be bonded into the revetment of the parapet, but their ends must be flush with the interior slope, so that if struck by a shot they may cause as little injury as possible.

279. **Splinter-proof Traverses with Fascines.**—The courses of fascines are laid as before. In every second or third course, the opposite fascines of the long sides are tied together

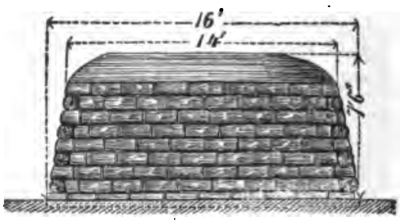


Fig. 106.—Splinter-proof Traverse.

with wire or rope; those of the short sides are anchored. The method of arranging the courses is shown in Fig. 106.

Eight fascines will revet 100 superficial feet.

The same remarks apply to the fascine revetment in dry sand, as to the gabion revetment.

280. **Sand-bag Revetment.**—A revetment is sometimes made of sand-bags laid in alternate courses of headers and stretchers, with the seams and ties of the bags towards the parapet. The parapet must be carried up simultaneously with the revetment, the sand-bags being well bedded in soft earth, beaten to the required shape and slope with mallets, and the earth carefully rammed in behind them. From time to time bags should be anchored by passing a rope around them and making it fast to a stake driven within the parapet.

281. **Embrasures with Sand-bags.**—The embrasures should be revetted with gabions or fascines if possible. When sand-bags are employed they must be covered with raw hides, or hurdles; otherwise they are soon destroyed by the blast of the piece.

One hundred and sixty sand-bags will revet 100 superficial feet.

282. **Sod Revetment.**—Sods may be used as a revetting material, when no other is procurable, but are not desirable for siege batteries, as they seldom stand at a less slope than $\frac{3}{1}$ and require much labor and time to build properly.

The sods should be 18″ long, not less than 9″ wide, and not more than $4\frac{1}{2}$ inches thick. They should be cut from a well-clothed sward, with the grass of a fine short blade, and thickly matted with roots. If the grass is long, it should be mowed before the sod is cut.

The sods are laid with the grass side downwards, and built as headers and stretchers. The layers should be laid perpendicular to the slope, as they will thus resist the outward thrust

better than if laid in horizontal courses. The sods should protrude a little beyond the plane of the interior slope, for the purpose of trimming the course even at top before laying another, and to make the interior slope regular. The sods should be bedded and backed with fine earth well rammed, the revetment being carried up at the same time as the parapet. Each sod is firmly settled by being tapped, as it is laid, with a spade or a wooden mallet. The different courses are laid so as to break joints with each other, that is, so that no two vertical joints in contiguous courses fall immediately over one another. The top course is laid with the grass side up. Small pegs $\frac{3}{4}$ inch in diameter and 9″ long are driven through each alternate course into the layers beneath, to connect the whole more firmly together. When cut from a wet soil, the sods should not be laid until they are partially dried, as otherwise they will shrink and the revetment will crack in drying. In hot weather the revetment should be watered frequently, until the grass puts forth.

283. **Hurdle Revetment.**—Hurdles may be used for revetments in very stiff soil requiring little support. They must be securely anchored into the parapet by pickets, or have long pickets driven well into the ground in front of them. In the former case, each hurdle must be anchored at both ends and at the middle by two withes or wires, one half way up, and the other at the top of the revetment.

When continuous hurdles are used, they should be made in the position required, and run in a continuous length along the parapet. For this purpose pickets are driven, at the proper inclination, about 16″ apart, and sunk about 1′ into the ground. Long and flexible rods are then paired on. The pickets are anchored by two rows of withes, one half way up, and the other near the top of the revetment. These withes are, in each row, from five to seven feet apart.

284. **Marsh Sod Revetment.**—When marsh sods can be procured, they make one of the best revetments. They should be cut 18″ square and 1′ thick, and thoroughly dried before being laid. They are built to break joints, pegs being driven through each course into the one below.

285. **Log Revetment.**—When time presses and timber in plenty is at hand, a revetment is sometimes made of logs laid horizontal, one over the other, along the interior slope, being anchored into the parapet by anchoring pieces notched in between every two layers. This revetment is objectionable, since a shot striking it will have its sphere of execution widely extended.*

286. **Plank Revetment.**—Wooden planks may be used for revetments in much the same way as hurdles, that is by driving long pickets into the ground in front of them, and anchoring these pickets at top.

287. **Pisa Revetment.**—A pisa revetment is a sort of earthen wall built up against the parapet. Ordinary earth is mixed with clay, and well kneaded, with just water enough to cause the particles to adhere when squeezed in the hand. Sometimes chopped straw is mixed up with the mass to cause it to bind better.

At the foot of the interior slope a trench is excavated 5″ deep and 18″ wide. A row of pickets is driven about 2″ from the foot of the interior slope, long enough to reach above the revetment when finished, and to be anchored by withes, ropes, or wires. Inside of these pickets is placed a course of planks, forming a coffer work. The revetment is then built up in courses 1½′ wide and 1′ thick, which are rammed throughout until their thickness is reduced by about one half, taking care

* Vertical post revetment will be described under head of Field Works, Part III.

to press the earth closely against the planks. When the revetment has reached the top of the first course of planks, the latter are pushed up along the pickets, or a new course is laid. The slope is trimmed off before the earth has become completely dry.

ELEVATED BATTERIES.

288. **Elevated Batteries, when Employed.**—In determining beforehand the construction of a battery, it should be borne in mind that the work should be done with the smallest number of men possible, and therefore an elevated battery should never be thrown up if the guns could do the same work when fired from a sunken or half-sunken battery.

The circumstances which necessitate the construction of elevated batteries are: water being found close to the surface, rocky soil, or the existence of obstacles in the line of sight. In selecting the site for a battery, the eye should be applied at points at the height above the ground of the line of sight of the guns to be used, and in the line of fire of the embrasures, in order to ascertain that nothing will prevent the guns being properly aimed. Obstacles to aiming guns need not be obstacles to firing, as guns are generally fired at angles of elevation.

289. **Tracing.**—Before proceeding to trace the battery on the ground an accurate drawing must be made, showing the direction of the parapet, epaulment, and communications, also the position of the traverses and magazine. The tracing on the ground must be made after dark, though if possible the direction of the parapet or the line of fire should be traced before dark.

We will suppose that an elevated six-gun battery is to be constructed, with traverses between the guns. (Fig. 107.) Let *a b* (Fig. 108) represent the foot of the interior slope of

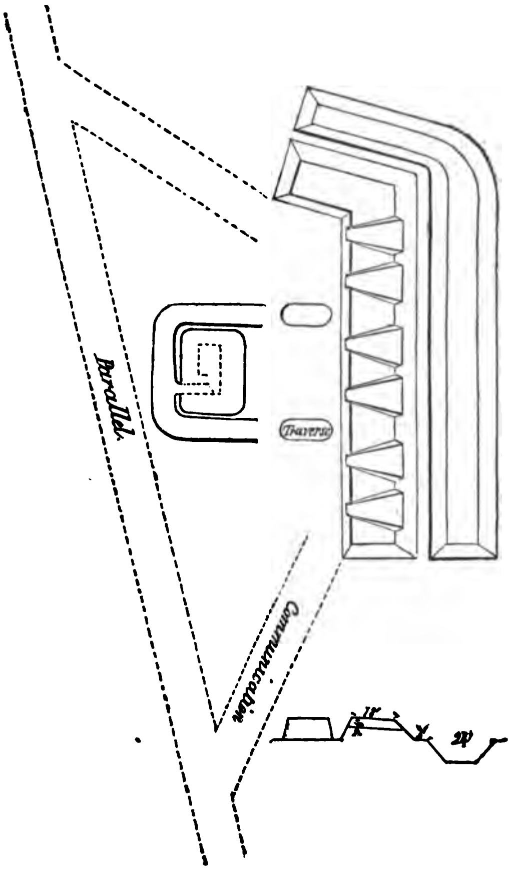


Fig. 107.—Battery for Six Pieces.

the parapet, $a\ c$ that of the epaulment. Lay off $a\ 1 = 9'$, 1, 2 $= 18'$. 1 and 2 will give the positions of the first and second embrasures. The next interval is 24′, as a traverse, which will occupy 6′, will come between the second and third gun. The other intervals are laid off in a similar manner, 15′ being

allowed for the extreme merlon on the side where there is no epaulment. The object of the epaulment being to screen the interior of the battery from oblique fire, the length and direc-

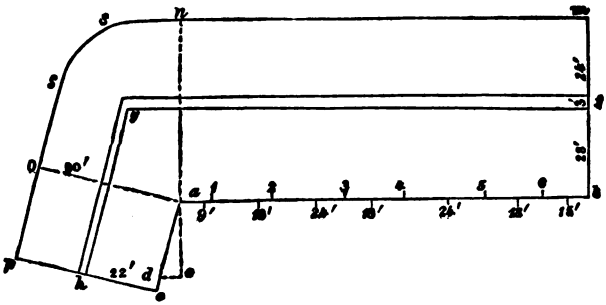


Fig. 108.—The Tracing of Batteries.

tion of the line *a c* will be dependent on the direction of this fire. The angle *c a b* having been previously determined, may be laid off either with a field level, or by constructing the triangle *a e d*.

By inspecting Figure 107, the thickness of the parapet at its base will be found 28′, and that of the epaulment 20′. These distances must be laid off on the perpendiculars, *b m*, *a n*, and *o c*, *c p*. Stout pickets are driven at *c*, *a*, *b*, *m*, *n*, *s*, *o*, and *p*, and tracing-tape stretched around them, thus enclosing the ground to be covered by the parapet.

The ditch is marked out in a similar manner, giving it a width of 24′ in front of the parapet and 20′ for the epaulments, and leaving a space of three or four feet from the foot of the exterior slope for the berm.

290. **Working Party—Organization.**—In the continental system of organizing working parties, soils are classified according to their degrees of hardness, as soil at 1 man, at $1\frac{1}{4}$, $1\frac{1}{3}$, $1\frac{1}{2}$, or 2 men. Soil at 1 man is very light soil, not requiring any picking; in soil at $1\frac{1}{4}$ men, 1 picker loosens earth

enough for 4 diggers; in soil at $1\frac{1}{3}$ men, 1 picker loosens enough for 3 diggers; in soil at $1\frac{1}{2}$ men, 1 picker loosens earth enough for 2 diggers; in soil at 2 men, 1 picker loosens earth enough for 1 digger. Ordinary soil is soil at $1\frac{1}{2}$ men, and difficult soil is soil at 2 men.

The diggers, provided with shovels only, are placed at intervals along the line of the ditch, and the proportion of pickers, provided with pick-axes only, is added according to the nature of the soil.

Rows of shovellers, equal in number to the diggers, are added according to the distance the earth has to be moved, each row being equal to moving it 6′ vertically or 12′ horizontally. The number of rammers is half the number of shovellers in the last row.

In order to arrive at the proper proportion of pickers, a few men are set to work on a piece of trench; each man is ordered to loosen the surface of his portion of trench all over, to the depth of one blow with the pick, and the mean time so occupied is noted. After that each man digs out the loosened soil and throws it to a mean horizontal distance of 12′, and the mean time occupied in this work is also noted. The operation is repeated, and the mean time required for picking (p) and that required for digging (d) give the data for apportioning the pickers to the diggers; thus if p is 4 minutes and d is 12 minutes, it is evident that 1 picker can loosen earth enough for 3 diggers, and the soil is therefore at $1\frac{1}{3}$ men.

291. **Posting Working Party.**—The working party organized upon the above principles, and provided with tools and revetting material, is conducted to the site of the proposed battery, as soon as it is dark enough to avoid being seen by the besieged.

The line representing the foot of the exterior slope is divided into lengths of 9′; for each length, supposing the soil to be ordinary soil, two shovellers and one picker are placed in the

ditch, one shoveller on the parapet to level, and one rammer to ram the earth thrown in, and one sapper to level the terreplein and prepare the ground for receiving the platform.

292. **Construction.**—The excavation is commenced 3′ from the line marking the crest of the scarp, and is carried down to the depth of 3′, then toward the counterscarp. As the ditch is intended merely to furnish earth for the parapet and not as a defensive work, its form is immaterial. That indicated in Figure 109 is generally found most convenient, the step fur-

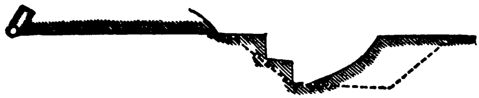


Fig. 109.—First Night's Work.

nishing a platform on which the earth from the outer part of the ditch is thrown; from there it is thrown into the parapet by a relay of shovellers. The steps are removed when the parapet is nearly finished.

When earth has been thrown into the parapet to the depth of 2′, the revetment of the interior slope is commenced. For this purpose five sappers for each one-gun portion of the battery are required.

Shovellers should be instructed to throw the earth at once to the rear of the parapet, always completing the portion against the revetments before that on the same level in front. A second row of shovellers should be introduced into the ditch, as soon as the diggers cannot throw up the earth for themselves; they shovel the earth from the step in the ditch on to the berm.

Rammers should never allow a greater depth than 6″ of earth to accumulate without ramming it. They must pay particular attention to the earth against the revetments. It is usually best to make unrevetted slopes at a steeper inclination than that required, and afterwards to cut off the superfluous earth with shovels.

During the first night, the terreplein should be prepared, the parapet and revetment carried to the height of the sole of the embrasure, 4′ above the terreplein for guns on travelling carriages, the traverses commenced, and the communications finished; the latter are constructed by the flying sap. As the excavation of the ditch is the most fatiguing part of the work, the men thus engaged change places with those on the parapet every two hours.

293. **Second Relief.**—The working party for the day arrive just before dawn, bringing with them gabions, fascines, &c. The working party for the ditch is the same as before, the excavation being deep enough to cover them from the fire of the place. They continue the excavation, throwing the earth on the berm, until no more can be piled there, then dig back toward the counterscarp, throwing the earth against the scarp ready to be passed up as soon as the berm is cleared on the following night. (Fig. 110.) The shovellers and rammers

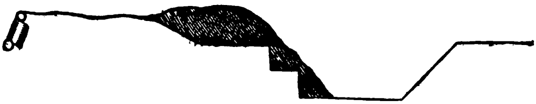


Fig. 110.—Work at the End of First Day.

will be prevented from working on the parapet by the fire of the besieged. They will be employed in finishing the communications, and the excavations for the magazine commenced on the previous night, and bringing up the timber for the platforms. The sappers will continue the revetment if the fire is not too heavy, and work at the magazine.

294. **Third Relief.**—The working party for the second night arrive at dusk; they are distributed as on the first night—the shovellers throwing in the earth accumulated during the day on the berm. The sappers finish the revetment, the platforms are laid, if they have not been during the day, and the battery armed.

295. **Ramp into the Ditch.**—When a battery has a ditch in front, there should always be some means of communication provided for the men working in it. A ramp in rear of the epaulment, 4′ wide at top and 2′ at the bottom, will answer the purpose, two men being employed in it as diggers, throwing their earth on to the epaulment; it will afterwards act as a means of draining the terre-plein into the ditch in front.

296. **Splinter-proof Traverses.**—Splinter-proof traverses, 16′ long and 6′ thick at the base, are formed of earth from an independent trench 10′ in rear of the traverse, 15′ long, 5′ deep, and 6′ wide. In difficult soil three diggers, and in easy soil two diggers, can excavate this trench, and with the assistance of two rammers and two shovellers, complete the traverse in two reliefs. The trench may be made available for receiving the drainage from the terre-plein of the battery, or it may be converted into a splinter-proof or a shell filling room. It must on no account be left uncovered.

Splinter-proof traverses may be built with a slope of $\frac{6}{1}$, as there is very little earth in them to cause them to bulge out.

297. **Removal of Tracing Tapes.**—The tracing tapes will be removed by the sappers, as soon as the fascines at the interior base of the parapet are laid and picketed, and the edge of the ditch cut all round the battery.

HALF-SUNKEN BATTERIES.

298. In the half-sunken battery the earth for the parapet is

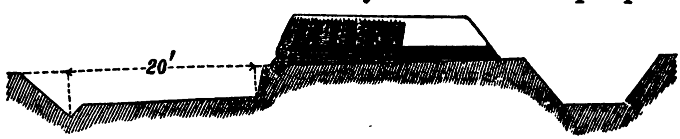


Fig. 111.—Half-sunken Battery.

supplied partly from the excavation of the terre-plein and partly from a ditch in front. (Fig. 111.)

299. **Tracing.**—To trace the battery, first mark out the base of the parapet and epaulment as before, except that 8′ are allowed for each splinter-proof traverse instead of 6′; then a line 20′ in rear of and parallel to the parapet, which will give the position of the foot of the reverse slope of the terre-plein.

300. **Posting the Working Party.**—For each one gun portion of 18′, six excavators (four shovellers and two pickers) are placed in the ditch, six on the terre-plein, and six sappers at the revetment of the interior slope. Two sappers, assisted by two workmen, level and ram the earth thrown into the parapet.

301. **Execution.**—The sappers commence the interior revetment by half imbedding a fascine at the foot of the interior slope. Parallel to this they commence excavating a trench 3′ wide and 2′ deep, leaving a berm of 18″ on the side next the parapet. The six excavators on the terre-plein excavate along the rear line of the terre-plein, throwing the earth towards the revetters, who pass it into the parapet, where it is levelled and rammed by the party stationed there. The excavators in the ditch begin on the side nearest the parapet. The depth of the ditch is 5′ and the width 12 or 14 feet.

302. **Time Required.**—In very easy soil the battery has been executed in one relief of 8 hours, but such a rate can be expected only under very extraordinary circumstances. Two reliefs in easy soil, and three in difficult, would appear to be a proper allowance for the ditch, and one in easy and two in difficult for the terreplein.

303. **Splinter Proof Traverses.**—A splinter proof traverse is built by a party of six men in the last relief. The solid earth having been left 8′ thick, the top of the traverse is formed of two rows of gabions, covering a space 5′ broad, with a berm 1′ 6″ wide all round. The traverse is generally attached in

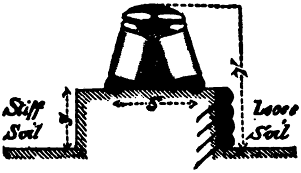


Fig. 112.—Section of a Traverse.

sunken and half sunken batteries. If the soil in which the battery is made is very loose, the lower portion of the traverse must be revetted with fascines, 9″ of the berms being cut off to allow room for them. (Fig. 112.)

304. **Drainage.**—The terreplein has an inclination to the rear, where it is finished with a trench to carry off the rain-water. If there is no low ground in the vicinity to which this trench can be conducted, it should terminate in a cess-pool.

305. **Revetment.**—The revetment of the interior slope is carried up to the level of the sole of the embrasure (four feet above the floor of the terreplein for guns on travelling carriages) with fascines. It may be finished either with fascines or gabions.

The method above described is only applicable when the soil is sufficiently firm to stand without revetment in the excavated portion of the interior slope. When this is not the case a trench is dug at the foot of the interior slope, and to the full depth of the terreplein. At the bottom of this trench the revetment is commenced and carried up, as in the elevated battery.

FULL-SUNKEN BATTERIES.

306. In full-sunken batteries, the terreplein being 3′ below the surface of the ground, sufficient earth is furnished for the parapet without any ditch in front.

307. **First Method of Construction.**—There are two methods employed in their construction. The first is similar to that of half-sunken batteries, the whole of the interior slope usually being revetted, and the ditch being omitted. The sole of the embrasure is 6″ above the ground at the interior, and

falls to the level of the surface in front. It must be carefully ascertained beforehand that no undulations or obstructions in the ground are in the line of sight of the guns.

308. **Second Method.**—The second method consists in converting a portion of trench into a battery. The trench may be purposely constructed by the flying sap, or a portion of parallel may be employed. In the latter case, a trench must be cut around, and thirty yards in rear of the battery, to replace the portion of the parallel thus occupied.

The front step of the parallel and about half of the berm (Fig. 113) are cut away, and the width of, the trench is in-

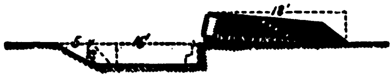


Fig. 113.—Conversion of a Parallel into a Battery.

creased to the rear, so that the terreplein shall be 20′ wide, 3′ deep in front and 3′ 6″ in rear. In cutting out the embrasure 4′ more than the usual width must be excavated, to allow room for placing the gabions in its cheeks.

Two diggers cut out the embrasure and revet it, two cut away the front step and berm, afterwards revetting it with four courses of fascines, and then act as shovellers to the diggers on the reverse of the trench. The latter are distributed at intervals of 4′ 6″.

INDENTED BATTERIES.

309. **Indented Batteries.**—Indented batteries may be constructed to utilize existing parallels, or dykes such as are found in a marshy country. The space necessary for each gun must be increased from 18′ to 22′ or more, according to the obliquity of the line of fire, so as not to allow the parapet to become too much weakened by the indents. The exterior of the parapet need not be indented, but the minimum thickness must be retained when the parapet is exposed to direct fire.

The least angle the line of fire should make with the general direction of the parapet is 45°. Indented batteries, being more troublesome to throw up than ordinary batteries, should never be made use of unless their construction is absolutely necessary.

310. **Tracing.**—When an elevated indented battery is to be placed on a narrow ridge of ground, a line *a d* (Fig. 114) must

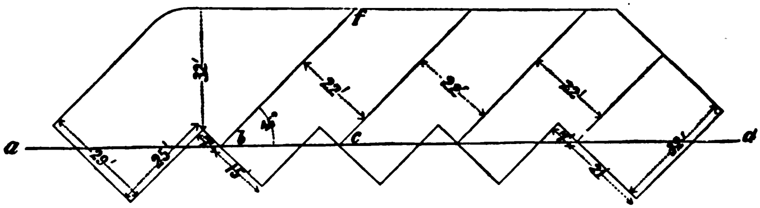


Fig. 114.—Trace of an Elevated Battery.

be traced, in rear of which there must be 20′ to give room for the terre-plein. If the battery is to be made on an already existing line of parapet, *a d* should be on its crest line. Mark with a picket the point *b*, for the centre of the first embrasure, and through it trace *b f* the line of fire; through the point *b*, at right angles to *b f*, trace a line for the interior base of the parapet, making the indent 7′ and the outer part 15′ long. If the battery is to be sunken or half sunken, 1′ 6″ must be added to these dimensions for the berm. At a distance of 22′ for an elevated battery, and of 23′ 6″ for a sunken or half-sunken battery, from the first line of fire, trace the second line of fire and lay off the merlon as before. The tracing of the other gun-portions is continued in the same way, 6′ being added for the extreme half-merlon. The cutting line of the ditch is then traced 32′ from the base of the most advanced merlon, and also from the indents, so as to allow of a minimum thickness of 18′ for the parapet of an elevated battery. Allow 25′ for the length of the epaulment, and trace the cutting line of its ditch 29′ in front, to allow of the minimum thickness of 12′ of para-

pet and an unrevetted interior slope. For sunken batteries the exterior line is traced 23′ 2″ from the angles of the indents, and 22′ 8″ in front of the interior base of the epaulment. For half-sunken batteries these distances are respectively 28′ 9″ and 25′.

311. **Profiles, Working Party, &c.**—The various dimensions of the profiles of parapets are the same as for ordinary batteries, with the addition of the interior projections. The diggers are placed in the ditches at intervals of 4′ 6″. The proportion of rammers must be increased, on account of the greater length of interior revetment as compared with the length of the battery.

HOWITZER BATTERIES.

312. **Howitzer Batteries.**—Batteries for howitzers are constructed like those for guns, except that the mouth of the embrasure is made 1′ wider than for a gun. This increase in the width of howitzer embrasures is rendered necessary by the shortness of the piece, which prevents the muzzle entering the embrasure, and renders the effect of its fire on the cheeks very violent.

MORTAR BATTERIES.

313. **Mortar Batteries.**—Unless the nature of the soil is unfavorable, mortar batteries are always sunken. They are without embrasures and, unless the soil is very light, are not revetted. A mortar battery to fire obliquely need not be indented; the length of the parapet is determined by allowing an interval of 15′ between the lines of fire.

In a direct mortar battery, the intervals between the axes of the mortars should be 15′. (Fig. 115.) Eight feet is added to the interval in which the traverse occurs. A space of 10′ is allowed between the axes of the extreme mortars and the

epaulment. The width of the terreplein is 20′ at bottom; its

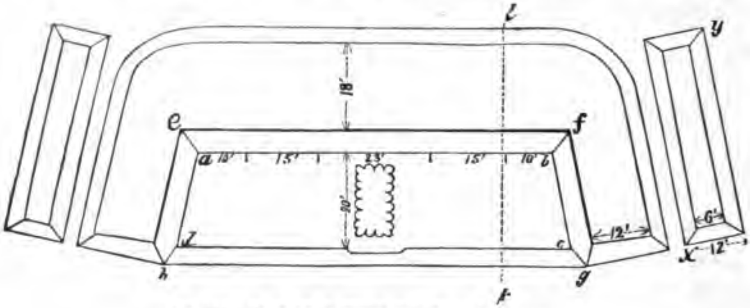


Fig. 115.—PLAN OF BATTERY FOR FOUR MORTARS.

depth in front 3′ 6″, and in rear 4′. The interior slope in ordinary soil may be $\frac{3}{2}$.

314. **Tracing.**—Mark on the ground the line representing the foot of the interior slope, and lay off on this line 73′, the sum of the intervals. From each extremity lay off the epaulments; their direction will depend on that of the enemy's fire. Parallel to the first line and 20′ from it, lay off the foot of the reverse slope. Then mark, with tracing tape, the lines *hegf*, 30″ outside the lines first laid out. These lines will be the intersections of the interior slopes of the parapet and epaulments with the natural surface of the ground. Parallel to the last lines, and 25′ 6″ distant for the parapet and 19′ 6″ for the epaulment, trace the foot of the exterior slopes.

315. **Execution.**—The excavation is commenced on the line *a b*, by sinking a trench 40″ deep and 4′ wide, the workmen being distributed at intervals of $4\frac{1}{2}$ feet, according to preceding principles. The earth is thrown into the parapet and passed forward by a relay of shovellers to form the exterior slope. When the above trench is finished, the excavation is carried back towards the reverse.

As soon as the parapet has attained its full height on the exterior, the sappers commence building the interior slope *o p*

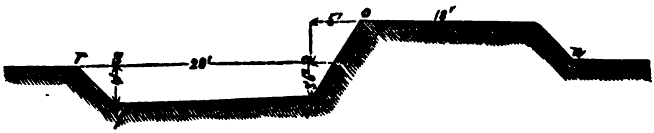


Fig. 116.—Section on *k l* Fig. 115.

(Fig. 116). The earth required for this purpose is thrown on the berm. When the excavation of the terreplein has been carried back to the line *r q*, the step *a m p* is cut away, and the earth thrown on the parapet. The earth obtained from the excavation of the terreplein is about sufficient for the construction of the parapet. That for the epaulments will be furnished by the ditches *x y* on the exterior.

When the soil is of such a character as to require the interior slope to be sustained, the usual revetments may be employed.

316. **Conversion of a portion of Trench into a Mortar Battery.**—Portions of a trench or parallel are frequently converted into mortar batteries. To effect this it is only necessary to increase the width of the trench to 20′. The earth thus furnished is thrown in front of the parapet, thus giving it the requisite thickness.

BREACHING AND COUNTER BATTERIES.

317. **Position.**—The crowning of the covered way is a trench constructed by the half double sap (par. 245), the crest of the parapet being parallel to and 18′ from that of the covered way. In this trench the breaching and counter batteries are constructed.

The traverses employed for the defilement of the trench are usually far enough apart to allow the introduction of two pieces between them. The intervals between the pieces may be

reduced to 14′. The line of fire in the breaching battery should be as nearly perpendicular to the scarp to be breached as possible; if the angle is less than 30° the shot will ricochet, and the breach cannot be effected. The profile of the scarp to be breached, and of the ditch and covered way in front, should be ascertained. This will determine the position of the directrices, and inclinations of the soles of the embrasures.

318. **Dimensions.**—The parapets of these batteries are 18′ thick and 8′ high. In each the terreplein is 19′ wide.

319. **Construction.**—During the day all the necessary material is collected, the terreplein excavated, and the platforms laid.

If the trench has been well constructed (par. 245 and following), and the soil is good, the revetment of the trench may be retained for that of the battery; otherwise a new revetment must be constructed inside of the former and beginning at the bottom of the trench.

The directrices of the embrasures are determined, and four pickets driven to mark the position and height of the corners of the platforms.

The excavation of the terreplein is commenced, part of the earth thus furnished being used in forming the foundations of the platforms, the remainder in increasing the height of the adjacent traverses.

320. **Embrasures.**—The embrasures are sapped out from the inside. The gabion where the throat of the embrasure is to come, is first pulled out; then one man, working on his knees, removes sufficient of the parapet from the front and sides to allow of a gabion being placed in each cheek, throwing the earth to the front. This done, the excavation is continued to the front to provide room for another pair of gabions. Two men work in the embrasure as soon as there is room for them, always throwing the earth to the front to provide cover,

and are relieved as soon as they have placed a pair of gabions. The work is continued until six pairs are placed. During this operation, the direction of the cheeks and inclination of the sole are indicated to the workmen by a straight-edge resting on the heads of two pickets, one in the throat of the embrasure, the other in the terreplein.

After the embrasure is finished, the mask in front is either removed by hand, or left to be blown out by the first discharge of the piece.

321. **Increasing Thickness of Counter Battery.**—It is sometimes desirable to increase the thickness of the parapet of the counter battery, since it is more exposed to fire than the

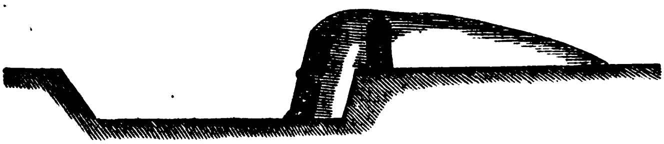


Fig. 117.—Counter Battery.

breaching battery. This thickness is gained from the inside, and it will be necessary to renew the revetment. (Fig. 117.)

PLATFORMS.

322. **Platforms Furnished with Guns not Durable.**—The platforms for guns and mortars, described in the U. S. Heavy Artillery Tactics, edition of 1864, pp. 90 and following, are found not to stand much firing.

323. **Means of Strengthening Them.**—The strength of the gun platform may be increased by burying under the sleepers, transverse skids of 8″ timber, 2½ feet apart from centre to centre; and that of the mortar platform by the same device, in addition to anchoring a heavy log immediately in rear of it.

324. **Gun Platform for Long Continued Practice.**—If the gun platform is to stand long continued practice, it may be constructed as follows.* The earth for the foundation is prepared by thorough ramming. Sleepers of round timber 9″ in diameter and 18′ long, hewn on the upper side, are bedded in the earth, parallel to the axis of the embrasure, and 2′ apart from centre to centre, being 6″ higher at the rear than at the front. On these are laid transversely hewn timbers 14′ long, 6″ thick, and from 10 to 14 inches wide. A hurter† of 6″ timber is placed at the forward end of the platform, at a distance from the parapet just sufficient to keep the wheels of the carriage clear of the revetment.

325. **Position of Mortar Platform.**—The front end of mortar platforms should be about 12′ from the interior crest.

POWDER MAGAZINES.

326. **Magazine Space Required.**—In every siege battery magazine accommodation should, if possible, be provided for the total quantity of ammunition to be fired in 24 hours, or at all events for enough ammunition to last from daybreak until the magazine can be replenished soon after dark. It is considered that 20 rounds per hour can be fired with accuracy from a gun by day, and that 10 rounds per hour should be fired by night to prevent the enemy repairing his works. Assuming that there are 14 hours of daylight, magazine accommodation should therefore be provided for 380 rounds per gun. It is desirable that there should be one magazine for every two guns.

* See General Barnard's Report on the Defences of Washington.

† The hurter is a piece of wood or a fascine, laid at the front of a platform to prevent the wheels of the gun damaging the parapet.

327. **Position.**—They are usually built 12 or 15 yards in rear of the parapet of the battery, sometimes at the end of the battery parapet. The best position is in rear of a traverse or merlon.

328. **Construction.**—The entrance should be so constructed that splinters of a shell exploding near it, could not penetrate into the body of the magazine. The latter is usually made 5′ high and 6′ wide, the length depending on the quantity of space required.

Figure 118 represents a rectangular magazine in rear of the parapet. An excavation 4′ deep receives the five mining

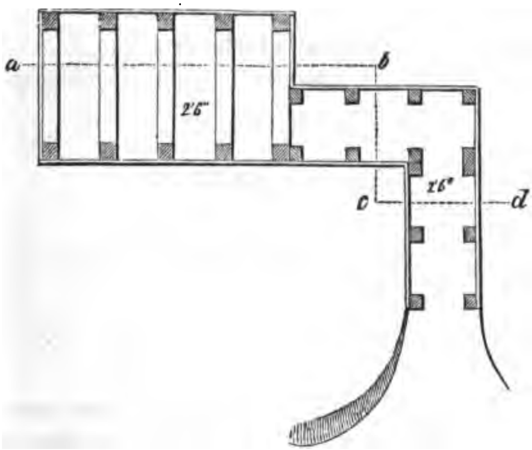


Fig. 118.—Plan of a Magazine.

frames, each composed of a cap-sill 7′ long and 8″ × 6″ in cross section, two stanchions 5′ 6″ long and 6″ square, and one ground-sill 7′ long and 6″ × 3″ in cross section. The intervals between the frames are 2′ 6″. The ground-sills are brought to the same level, and the frames are surrounded with sheeting at the sides one inch thick, and covered at top with timber or plank at least 6″ thick. The frames for the com-

munication may be of somewhat smaller scantling. These frames are 2′ 6″ wide in the clear, and of the same height as those in the magazine. The sheeting is also the same. The roof may be still further strengthened by layers of timber or fascines.

329. **Earth Covering.**—The whole must be covered with earth to the depth of 10′.

As a precaution against moisture a tarpaulin is spread in the interior of the top embankment. The earth having been raised about 2′ high in the middle, is shaped into the form of a roof. A tarpaulin is laid over it and the remainder of the earth thrown on. (Fig. 119.)

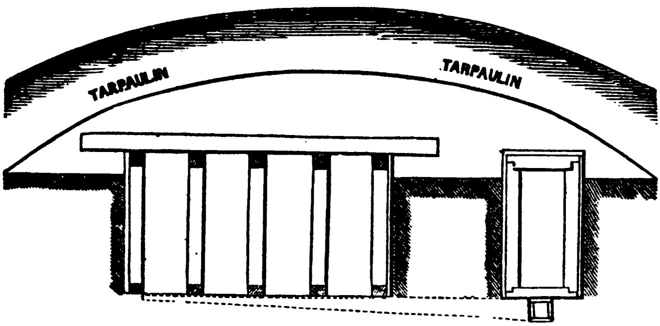


Fig. 119.—Section on *a b*, *c d*, Fig. 118.

The earth for this covering is partly furnished by the excavation for the magazine, and partly from a trench cut around it, a sufficient berm being left to prevent the embankment caving in.

330. **Level of Floors.**—If the soil is dry and the position an upland one, the magazine may with advantage be sunk several feet lower, making the chamber entirely below ground.

331. **Drainage.**—Drainage should be provided, by sinking barrels or gabions near the corners or the entrance. After the

magazine is loaded, it would be well to construct a mound of earth ors and-bags, 18″ high, in the passage of the magazine, to prevent water running in. The ammunition can be handed over it.

332. **Linings.**—When timber for frames is scarce, the interior of the magazine may be revetted with fascines, or with gabions crowned with fascines. In the former case the wall of fascines should slope outwards. In the latter case the gabions should be placed in two rows side by side, thus forming a double revetment.

GENERAL REMARKS UPON BATTERIES.

333. **Dimensions.**—As has already been hinted, the foregoing dimensions are not invariable. They are those most commonly used, and are to be varied according to circumstances.

For instance, if a battery were to be exposed to the fire of the heaviest guns, it would be necessary, besides increasing the thickness of the parapet to a minimum of 25′, to place the guns further apart (34′ from centre to centre), to prevent the possibility of a single shell bursting in a merlon filling up two embrasures, and thus silencing the fire of two guns.

334. **Screen.**—The accuracy with which shells can be thrown by rifled artillery will render the construction of batteries by day, or even by night if their position be known, under such fire either impossible or very dangerous. A battery cannot be completed in one night, and in order to prevent the work being interrupted the morning after the first night, it is necessary to keep its position secret from the enemy. The range of the guns in the new siege trains being now extended to 2,000 yards, it will generally be possible to select sites where the batteries during their construction will be concealed from

view by fences, shrubbery, etc. If this cannot be done, it may be well to throw up an artificial screen by the flying sap. It should extend along the whole front of the batteries, as it would be of no use to erect it exactly in front of the position only.

SECTION XII.—TRENCH CAVALIERS.

335. **Trench Cavaliers.**—A trench cavalier is a work thrown up about 30 yards from the crest of the glacis, to give a plunging fire upon the covered way of the besieged work. (Fig. 120.) Its height is determined by the condition that its

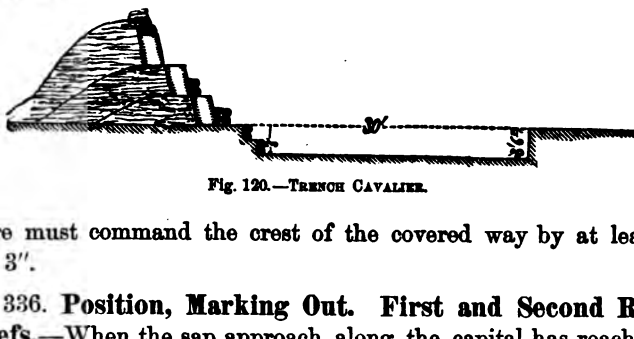


Fig. 120.—Trench Cavalier.

fire must command the crest of the covered way by at least 4′ 3″.

336. **Position, Marking Out. First and Second Reliefs.**—When the sap approach along the capital has reached a point 30 yards from the crest of the glacis, the limit of the range of hand grenades, two single saps are broken out from

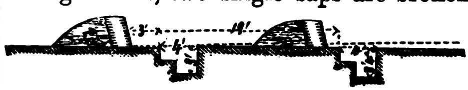


Fig. 121.

it. The saps are parallel to each other and have their cutting lines 19′ apart. The front one has a berm 3′ wide, the rear one the ordinary berm of 18″. (Fig. 121.) They are pushed at right angles to the approach, until they reach the prolongation of the face to be enfiladed, when they are made perpendicular to that face, and are so continued until the front one has advanced about 20 yards in the new direction. The latter is then obliqued to the left or right, (according as it is on the left or right of the capital of the besieged work) at an angle of about 45°, and continued 10 yards more, to cover from reverse fire. The rear sap is kept parallel to the front one. That portion of the first sap, intercepted between the crest of the glacis prolonged and the counterscarp prolonged, is to be converted into a trench cavalier. The rear sap is excavated 4″ deeper than usual. Its total length being 18′ less than that of the front sap, it should be finished about the same time. They should be completed in two reliefs.

337. **Third Relief.**—In the third relief the trench of the first sap is widened 6′ by infantry placed at intervals of 6′, excavating to the depth of 3′ in front, and 3′ 2″ in rear. This employs 15 diggers, and gives to each a task of about 111 cubic feet. They also build up and revet the lowest step with fascines.

338. **Fourth Relief.**—For the fourth relief two parties of 15 men each are required, who have to bring up 45 gabions between them. One party act as shovellers on the berm, and commence by placing the second tier of gabions 2′ in advance of the first tier, and afterwards fill them and go on with the parapet. The second party widen the trench 3′ 6″, throwing the earth on to the berm, and also remove the parapet and empty the gabions of the rear sap, leaving them in the trench. Their task is to excavate 67 cubic feet, and to shovel away 65 cubic feet more of the parapet of the rear sap. They have to revet the edge of the berm with fascines.

339. **Fifth Relief.**—For the fifth relief three parties of 15 men each are required, distributed at about 6′ intervals as before. One party acts as shovellers on the top of the first tier of gabions, and commences by placing the third tier of gabions 2′ in advance of the last tier. The second party acts as shovellers close to the bottom step. The third party cuts away the earth between the two trenches, giving a total amount of about 110 cubic feet per man. They also complete the step on the berm.

340. **Sixth Relief.**—For the sixth relief four parties of 15 men each are required, one party as shovellers on the tops of the first tier of gabions, one as shovellers in the terreplein close to the bottom step, one as shovellers midway across the trench, and one as diggers along the rear of the trench. The latter are distributed at about 5′ intervals, make the total width of the terre-plein 30′, and depth in rear 3′ 6″, and have a task of about 122 cubic feet per man. The shovellers on the top of the first tier of gabions have to crown the upper tier with three rows of fascines, and the shovellers near the bottom step have to form the step on the top of the first tier of gabions. The shovellers in the centre of the trench have to fill 100 sand-bags, and form on the tops of the fascines 25 loop-holes directed on the covered way.

SECTION XIII.—DESCENT AND PASSAGE OF THE DITCH, &c.

DESCENT WITH GALLERIES—BLINDED DESCENT—UNCOVERED DESCENT—PASSAGE OF DRY DITCH—PASSAGE OF WET DITCH WITH CURRENT—PASSAGE OF WET DITCH WITHOUT CURRENT—DESCENT INTO COVERED WAY.

DESCENT WITH GALLERIES.

341. **Galleries, when Employed.**—The descent into the ditch is effected by a great or principal inclined gallery (see Military Mining, par. 16) when the counterscarp has sufficient height to allow a mass of earth at least 3′ deep to be left between the terre-plein of the covered way and the roof of the gallery. This thickness is considered requisite by miners, in earth of ordinary consistency, in order that the construction may not be too difficult. It is useful also as a protection against vertical projectiles.

The great gallery is used in earth of ordinary consistency; in light sandy soil it is more prudent to use the principal gallery.

If the ditch is dry, the gallery should debouch 3′ below its bottom; if wet, 1′ above the highest level of the water.

342. **Commencing Descent.**—The height in the clear of these galleries being 6′ 6″ and the cap-sills 8½ or 8 inches deep, the total height of the excavation, allowing for the sheeting, must be about 7′ 6″, giving 10′ 6″ as the minimum dis-

tance between the surface of the ground and the floor of the gallery. To obtain this distance in the beginning by a shaft would require much time and labor, and the excavation thus made would catch the vertical projectiles of the enemy, so as to render the approach to the gallery extremely dangerous. Consequently the descent may have to be commenced, or even entirely formed when the ditch is less than 10′ 6″ deep, by means of a blinded descent.

BLINDED DESCENT.

343. **Blinded Descent.**—A blinded descent, or blinded gallery, or blindage, is a deep sap which is covered as it advances with fascines supported by blinds.

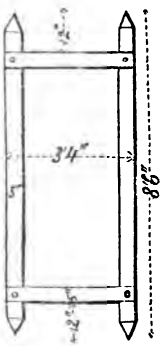


Fig. 122.—Blindage Frame.

344. **Blind.**—A blind is a frame composed of two uprights or stanchions, of 5″ scantling, (Fig. 122,) 8′ 6″ long, and pointed at both ends; and two horizontal pieces of the same sized scantling each 3′ 4″ long. The horizontal pieces are notched upon the stanchions at 12″ from each end. The width of the frame from out to out is 3′ 4″, the distance between the horizontal pieces from out to out 6′.

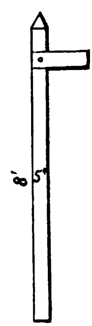


Fig. 123.—Auxiliary Frame.

345. **False Stanchions.**—An auxiliary stanchion, or false stanchion, consists of a single upright 8′ long, with a projecting piece 1′ long, attached 12″ from one end. (Fig. 123.)

346.—**Point of Departure.**—The point of departure is usually in the crowning of the covered way, 5′ below the sur-

face of the glacis, a depth which allows the requisite mass of fascines and earth to be heaped on the blinds, without projecting above the parapet of the adjacent trenches. In case the maximum inclination would be insufficient to make the descent debouch at the proper level, the point of departure must be lowered.

347. **Beginning the Descent.**—A debouch by the double sap is executed from the crowning of the covered way, according to the method described in Section X., with the exception that berms 2′ 2″ wide are left, in order to reduce the width of the trench at bottom to 7′ 8″, and instead of three brigades of sappers covered by four sap-rollers, two brigades covered by two sap-rollers are employed, one brigade executing a right handed sap and the other a left. When the sap-rollers have nearly cleared the parapet, the trench is excavated until the required depth for the descent, 5′ feet below the surface of the glacis, is attained. The slope given to the sides should be as steep as the nature of the soil will permit, 3 or 4 on 1 for ex-

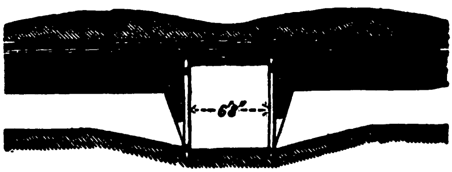


Fig. 124.—Section on A B, Fig. 125.

ample. At the same time a landing is formed in the crowning, at the point of departure of the descent, having the same depth as the latter. This landing is united with the terre-plein of the crowning by slopes. (Fig. 124.)

348. **Placing the Blinds.**—A vertical blind is placed on each side, the distance between the two in the clear being 6′ 8″. They are connected by a strong batten passing across the trench. When the excavation has advanced 2′ beyond these

blinds a horizontal blind is placed over the trench, one side resting on the two vertical blinds, the other on two false stanchions in advance. The latter are placed one on each side and about 30″ from the axis of the descent; their height is such as to raise the front side of the horizontal blind from 4 to 6 inches above its true position. (Fig. 125.)

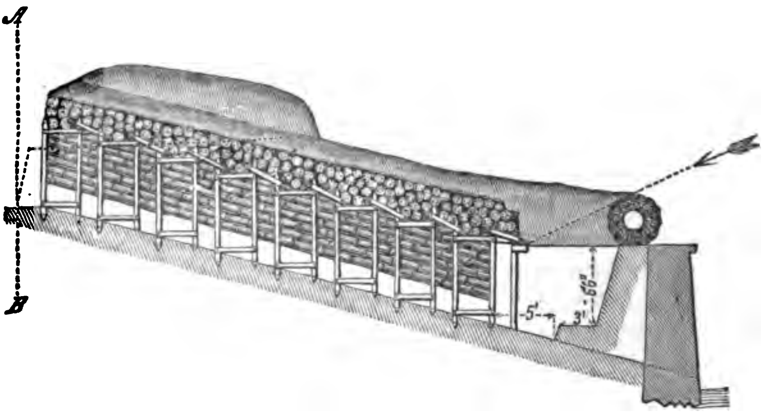


Fig. 125.—Blinded Descent.

349. **Excavation.**—The excavation is continued by the double sap. It is executed by two sappers, who dig to the full width and depth of the descent, throwing the earth over the lateral gabionades, unless the depth should exceed 6′ 6″. In that case, the leading sappers dig only to that depth, and are followed by two others, who complete the excavation, leaving a banquette a yard long for the first to stand on, and removing the earth in wheelbarrows to the rear, where it is thrown on to the parapet of the crowning by other sappers.

350. **Gabionades Dispensed with.**—When the head of the descent has attained a depth of 6′ 6″, the lateral gabionades may be dispensed with. The leading sappers continue to form parapets on the right and left, however, moving the sap-

rollers forward gradually. A portion of the parapet will fall forward against them, and a quantity of loose earth should be held in readiness to throw into the gap.

351. **Continuation of the Blindage.**—New lateral blinds are introduced when the excavation has advanced 5′ from the last placed vertical blinds. For this purpose, two holes are made on each side, to receive their feet, one 2′ from the nearest stanchion of the last blind and 14″ deep, the other 3′ from the first and 4″ deep, supposing the inclination of the descent to be ¼. The lateral blinds are then placed, their tops engaged under the previous horizontal blind, and the false stanchions removed.

352. **Remark on Placing Blinds.**—The lateral blinds should be placed as nearly vertical and in the same alignment as possible without delaying the work. An attempt to place them with great accuracy would cause unnecessary delay. It is sufficient to place carefully the first two on each side, to guide the position of the following.

353. **Covering with Fascines.**—When the excavation has advanced 2′ further, another horizontal blind is placed as before, with the false stanchions. As soon as the horizontal blinds are in position, they are covered with 3 or 4 courses of 9′ fascines, by the sappers at the head of the work. The latter seize the fascines, one at each end, throw them up on the blinds, and arrange them with their forks. They then cover them with raw hides or earth, to prevent their being set on fire.

The spaces between the lateral blinds and slopes of the excavation are then filled with fascines from 3 to 5 feet long.

354. **Covering Roof with Earth.**—As soon as the lateral parapets have acquired sufficient thickness to protect the head of the work, earth is thrown to the rear, on to the roof of the blindage.

355. **Marking Direction, &c.**—As the excavation advances, pickets are driven at intervals of 1 yard, to mark the direction and inclination.

356. **Lowering the Sap-rollers into the Covered Way.**—Soon after the beginning of the descent, a delicate operation has to be executed; viz. lowering the sap-rollers down the interior slope of the covered way. The sap-rollers being securely fastened together, a stout picket is driven into the ground at each end of the rollers. Ropes are made fast to these pickets, passed *under* the rollers and *over* them back again, to act as checks. (Fig. 126.) If there are no palisades in the covered way, or if they have been so damaged as not to project above

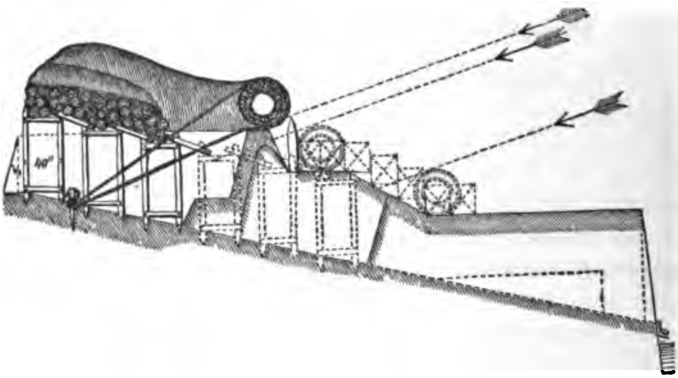


Fig. 126.—Blinded Descent.

the crest of the glacis, the rollers are pushed forward with sap-hooks, and allowed to fall on the banquette, being checked by the ropes. If there is a good palisading, with points projecting above the crest, the rollers are raised a little with levers, and 3 or 4 planks are slipped under them and placed with one end resting on the glacis, the other on the palisading, thus forming a ramp for the rollers to pass over. The same end may be attained by throwing sand-bags into the interval be-

tween the palisades and the interior slope, heaping them up above the points of the palisades.

In either case, great attention must be paid to the ropes by which the rollers are retained. Equal attention must be paid in descending the banquette slope, so that the roller may not get so far in advance as not to cover the head of the descent.

357. **Working Party, Tools, Time.**—Ten sappers are employed. The two at the head of the work should be frequently relieved. They are provided with all the tools necessary for the double sap and for mining. In ordinary soil, the descent will advance about 1′ per hour.

UNCOVERED DESCENT.

358. **Uncovered Descent.**—The sap by which the descent is effected into a very shallow ditch, without employing a blindage, is termed an uncovered descent. From the difficulty of defiling it, it must usually be very narrow and much deeper than the ordinary sap. Otherwise there is nothing peculiar in its construction, except the difficulty of firmly placing the gabions on the slope of the descent.

PASSAGE OF A DRY DITCH.

359. **Passage of a Dry Ditch.**—When the ditch is dry, the passage is effected by means of a trench sapped across it in the usual manner. The sap should be commenced from the great gallery, the bottom of which should be at least 3′ below the level of the ditch. A parapet of sand-bags, fascines, or a sap-roller, (passed down the gallery end foremost on rollers) should be formed to cover No. 1 sapper, when commencing work, from flank fire. It may be necessary for the sap to be deeper than usual, owing to the command of the place.

PASSAGE OF A WET DITCH WITHOUT CURRENT.

360. **Passage of a Wet Ditch without Current—Causeway.**—When the ditch is wet, but there is no current, the passage may be effected by constructing a causeway of fascines, with a parapet on one or both sides. Six-feet fascines are the best for the purpose; they must be prepared beforehand, with stones, &c., bound up in them, to make them sink. The fascines are passed from hand to hand by men placed at intervals along the gallery, and are thrown in until a platform has been made about one foot above the level of the water, of the necessary width for the roadway and parapet, and about 10′ long.

361. **Wall of Sand-Bags.**—The next operation is to form a wall about 6½ feet high of sand-bags, in the form of a horseshoe, to protect the front and flanks from the enemy's fire. Sand-bags only half-filled, or better still, small bags made especially for the purpose, passed from hand to hand down the gallery are thrown out to form the wall. When the wall is sufficiently high, sappers place themselves under cover of it, with their backs to it, and throw the sand-bags passed to them over their heads.

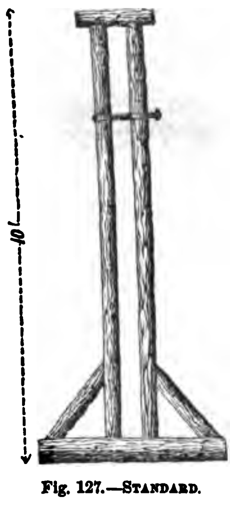


Fig. 127.—STANDARD.

362. **Musket-proof Shutter.**—The wall having been completed up to the full height of 6½ feet, a musket-proof shutter, composed of two standards with planks between them, (Fig. 127,) is erected in the lodgement that has been formed; this protects the gallery from fire from the front.

363 **Continuation of the Causeway.**—The causeway must next be lengthened by fascines passed from hand to hand down the gallery, and thrown over the sand-bag wall by men under cover of it. When the causeway has been advanced 5 or 6 feet, the front wall is moved forward by men gradually removing the sand-bags from the inside, and throwing them more to the front and sides, more sand-bags being required for the latter.

The front wall of sand-bags having been advanced about 8′ from the counter-scarp, the side walls are revetted. Two 6′ fascines are laid on both sides, and 3 gabions placed vertically on them, filled and backed with sand-bags. These gabions should be 4½ feet high, specially constructed for the purpose. On them should be placed two fascines, and a third on top of all. (Fig. 128.) The standards should then be moved for-

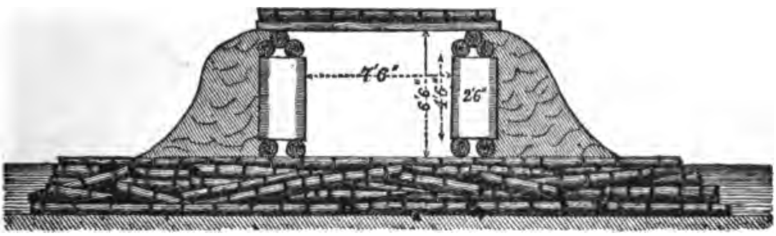


Fig. 128.—Section. Passage of Wet Ditch without Current.

wards, and blindage frames laid across the top from side to side of the causeway. The blinding is then completed by means of planks or fascines. (Fig. 129.)

364. **Means of Facilitating the Operation.**—The time occupied in the passage of a ditch would depend much on the fire of the enemy, and also on the facility with which the materials required for the roadway and parapet were brought to the spot. The operation may be facilitated by driving a return, from 10 to 15 feet in length, on each side of the great

gallery, behind the revetment of the counterscarp, the earth being thrown into the ditch to assist in forming the causeway.

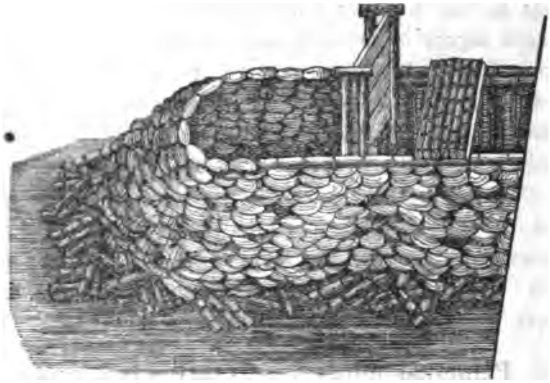


Fig. 129.—Passage of Wet Ditch without Current.

Much time has been saved by constructing two galleries of descent, one of which was used for building the parapet and the other for the roadway.

PASSAGE OF A WET DITCH WITH A CURRENT.

365. **Difficulty of the Operation.**—When the wet ditch has a current, the difficulty of passing it is very great, and if the stream be deep and rapid or the garrison have much command of water so as to empty and fill the ditch at pleasure, the difficulties are considerably increased. The utmost care and address will hardly secure success, unless the fire of the place is totally extinguished.

The passage must be effected either by a floating bridge, or by a causeway with openings in it, for the water to flow through.

366. **Cormontaigne's Method at Philipsburg.**—Cormontaigne employed a floating bridge of fascines with perfect success at the siege of Philipsburg in 1734. It consisted of alternate layers of fascines laid crossing each other at right angles, with hurdles between them, and fastened together with pickets. Its width was 48′ at bottom, and its thickness 6′. A parapet was formed by a double row of gabions with fascines on them, covered with fresh raw hides to prevent them being burnt. Two such bridges were made in 6 days across ditches 128′ wide, in which there was from 12 to 15 feet of water, with a loss of not more than 20 men at each bridge; but it appears doubtful whether there was a very rapid current.

367. **Principal points for attention in Floating Bridge with Fascines.**—The principal points to be attended to appear to be:

1st. To place the fascines in successive layers crossing each other at right angles, alternately with hurdles interposed at intervals.

2d. To lay each successive course of fascines within the preceding one, in order that the bridge may not turn over when laden with its epaulment.

3d. At every three layers to drive pickets into the fascines.

4th. To build the epaulment itself considerably within the edge of the bridge, and increase the buoyancy of that side of the bridge.

5th. To cover the whole with raw hides, or in some other way to prevent the bridge being burnt.

368. **Causeway with Water Way.—Construction of Cylinders.**—The most practicable method with a strong current, appears to be by means of a causeway composed of a

sufficient number of layers of open cylinders, with their axes in the direction of the current. Each cylinder is made of gabions or headless casks, placed end to end, and lashed together at three equidistant parts of their circumference. Holes are made through the casks, or staples driven about 10″ from their ends, for the lashings; or, the gabions or casks of each cylinder are lashed to two or more baulks on opposite sides, which give it greater stiffness and allow it to be more easily got into position.

369. **Placing the Cylinders.**—Each cylinder is carried down the gallery in succession, weighted by means of shot, stones, &c., in sand-bags, launched, hauled into position by means of guy-ropes at each end, and sunk. Layer after layer is sunk until the upper one appears above the water, when the interstices are filled up with fascines, and a roadway formed by others laid at right angles to them.

370. **Floating Mask.**—A floating mask may be necessary for the protection of the men forming the head of the bridge. The mask should be of planks covered with iron or steel plate, if possible. It is placed on a floating raft of logs, which must have sufficient buoyancy to support it, and two sappers to manœuvre it. The raft may be composed of two layers of logs 9″ × 6″ in cross section. It is put together in the gallery, and after being launched, the mask is placed on it and secured by stays.

371. **Epaulment.**—As the work proceeds, an epaulment must be erected on the causeway under cover of the mask, to protect the men from the flank fire of the enemy. It should always be remembered that even if an epaulment be not musket-proof, it affords great protection to men, as it screens them from sight.

DESCENT INTO THE COVERED WAY.

372. **Blinded Descent.**—This is nothing more than a blinded descent, executed by the process described above. It is usually made opposite to a traverse of the covered way. Having descended into the defile of the traverse, a debouch by the sap is made into the terre-plein of the covered way.

373. **Uncovered Descent.**—When not exposed to a plunging fire, the uncovered descent may be employed for this purpose.

PART III.

DEFENSIVE WORKS.

PART III.—DEFENSIVE WORKS.

Section XIV.—FIELD WORKS.

Tracing.
Defilading.
Profiling.
Revetments.
Magazines.
Bomb-proofs.

Section XV.—INTRENCHMENTS.

Remarks.
Shelter Trenches.
Rifle Trenches.

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Abatis.
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Palisades.
Fraise.
Trous-de-loup.
Wire Entanglement.
Chevaux-de-frise.
Crow's feet, &c.
Barricades.
Inundations.
Fougasses.
Torpedoes.
Stockades.

SECTION XVII.—DEFENCE OF WALLS, &c.

SECTION XIV.—FIELD WORKS.

TRACING — DEFILADING — PROFILING — REVETMENTS—MAGAZINES—BOMB-PROOFS.

TRACING.

374. **Tracing like that of a Battery.**—A field work is traced in the same way as an elevated battery (par. 289). The lines traced are the cutting lines of the ditches and the bases of the slopes. When the tracing has been completed, the lines may be marked with a pick, and the tapes removed.

DEFILADING.

375. **Definition of Defilement.**—Defilading, or defilement, is the operation of regulating the direction and relief of the covering masses so that the interior of the work may be screened from the view of the enemy. The regulation of the direction of the lines is called defilement in plan; that of the relief, defilement in section.

376. **Defilement in Plan.**—This object must be constantly kept in view, in choosing the outline of the works; for among the different tracings which may be used, some will be much more easily defiladed than others.

When a work is thrown up in front of a height, it is the more difficult to defilade in proportion to its depth. It should

therefore be given an oblong form, all other things being equal, and its longest faces be traced parallel to the height.

As a general rule, the prolongation of the principal faces should be directed on lower ground, or on parts where the enemy cannot place his artillery within effective range. The salients will occupy commanding ground, while the re-entrants should occupy the lower portions.

377. **Defilement in Section.**—After a careful selection of the trace, the defilement is made complete by the defilement in section.

378. **Plane of Defilement.**—On a horizontal site a command of 8′ is sufficient to cover the interior of a work. On an irregular site (Fig. 130), if a plane be conceived passing tan-

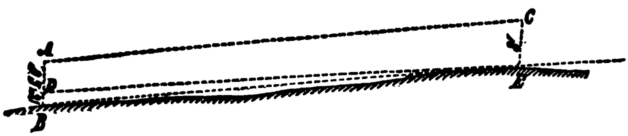

Fig. 130.—PLANE OF DEFILEMENT FOR MUSKETRY.

gent to the dangerous ground and through the point of the interior most distant from this dangerous ground, it may be considered the plane of site; and it is evident that if the interior crests of the parapet be placed in a plane parallel to this plane of site and 8′ above it, the interior of the work will be covered as completely as in the former case. This inclined plane of the interior crests is called the plane of defilement. In the case taken it passes 8′ above the dangerous points.

This height is necessary, however, only in defilement against musketry. Artillery fires from a height of only 4′ above the ground. Hence the plane of defilement against artillery may pass 8′ above the interior of the work and 4′ above the danger-

ous ground (Fig. 131), and the plane of site may be conceived as parallel to it and 4′ below it, or, in other words, as passing

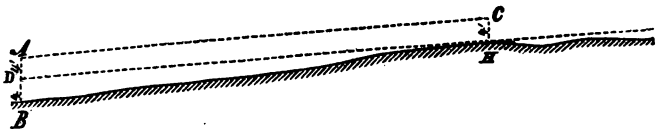

Fig. 131.—Plane of Defilement for Artillery.

tangent to the dangerous ground and 4′ above the point of the interior most distant from it.

379. **Practical Defilement against Artillery.**—The effective range of musketry being 500 yards and that of field artillery 2000 yards, the ground from 500 yards to 2000 yards distant is dangerous only from artillery. To defilade from ground within those limits, then, it is required to find practically a plane which shall contain the point D (Fig. 131) and be

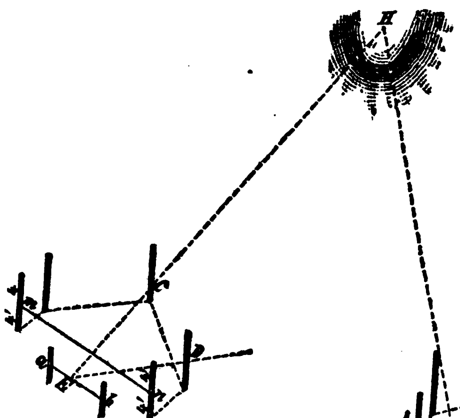

Fig. 132.

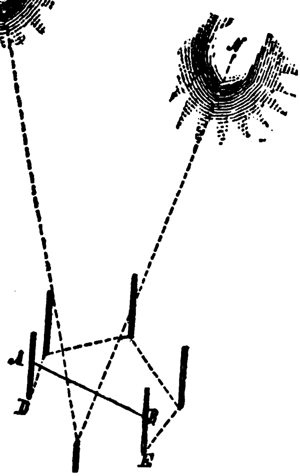

Fig. 133.

tangent to the point H. The following method of finding the required plane is general, and applied in this example to a lunette.

After having planted poles at all the angles of the lunette, (Fig. 132) and stretched a cord *m n* 4′ above the gorge line, hold a straight edge *a b* between two pickets driven a few yards in rear of the work; elevate or depress the straight edge, until the lines *m n* and *a b* are both in a plane tangent to the height H.

If then the eye of the observer be placed at any point of the line *a b*, the visual ray E H, drawn through the pole C at the salient angle of the lunette, will show the height of the plane of site at the point C. In a similar manner the point D, at the angle of the shoulder, or any other point required, may be found. To each of the heights so obtained add 4′, and saw off the poles at that height; their tops will then show the height of parapet required, which should generally be less than 12′.

380. **Means of Reducing the Relief.**—If the relief exceed the maximum allowed, it may be reduced by lowering the line *m n* 1½ feet, which will still leave a relief of 6½ feet at the gorge. If this means be insufficient, recourse must be had to traverses, or the ground be lowered at the gorge. The latter might in some cases be the least laborious operation.

381. **Defilement against Musketry.**—When the dangerous points are within 500 yards of the work, the plane of site must pass through the foot B (Fig. 130) of the picket placed at the gorge of the work; for the height C H, from which it is then necessary to be defiladed, is equal to that A B of the parapet at the gorge.

The plane of site passing through B and H would be very difficult to determine in the manner before described; but if we suppose it to pass 1½ feet above the ground at the gorge, the observer will then be enabled to ascertain the direction of

that plane as before. Instead of setting off 6½ feet on each of the poles planted at the angles, to determine the plane of defilade, set off from 7 to 7½ feet on the pole planted at the salient, above the plane of site, and the work will be well defiladed.

382. **Plane of Site with Plane Table.**—With the aid of a plane table, the plane of site might be more accurately determined. If the upper surface of the plane table were placed in a plane tangent to the dangerous ground, the intersections of that surface prolonged, with the poles planted at the angles, would show accurately the heights of the plane of site.

383. **Defilement from Two or More Heights.**—If it were required to defilade from two or more heights, then the plane of site being at once tangent to two points of the exterior ground, could not be made to contain a given line at the gorge, as in par. 379, but only a point of that gorge; for instance, a point near the centre of it, which point must be raised 4′ when it is required to defilade from artillery and 1½ feet when from musketry.

Let H and N (Fig. 133) be two heights from which it is necessary to defilade from artillery. In the centre of the gorge of the work, or at the point most distant from the given heights, plant a stake projecting 4′ above the ground. In front place two other stakes, D and E, and cause a straight edge to be moved up and down on them, until, when seen from the end of the first stake, it appears to touch at the same time both the points H and N. The plane thus found will evidently be the plane of site; and to the heights obtained by it, 4′ are to be added as before. Instead of a straight edge, a tape or cord may be used.

384. **Two Planes of Defilement.**—It often happens, in the case above described, that a single plane of defilement would give too great a relief. The left part of the work must

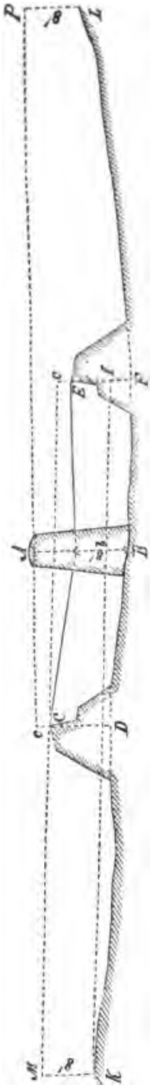

Fig. 134.

then be defiladed from the height H, and the right part from the height N.

385. **Traverse Required.**—This method exposes the faces to be enfiladed or seen in reverse, and will consequently render it necessary to erect a traverse to cover them. The traverse is usually made on the capital; and its height should be sufficient to screen the troops, when mounted on the banquette, from the reverse view of the enemy.

An enclosed work constructed on the slope of a hill, having a plain on one side, always requires a traverse to cover it from the slant or reverse fire of the plain; so that a plain is as dangerous to a work constructed on the slope of a hill near it, as the hill would be to the same work constructed on the plain.

386. **To Find Height of Traverse.**—Let A B (Fig. 134) be the central line of a traverse, and C D, E F, the two opposite parapets of a redoubt, to be defiladed from musketry. On the side of the plain, the parapet E F would be made 8′ high; but the height of the parapet C D, on the other side, must be so regulated that the plane of defilement may pass 8′ above the ground at the axis of the traverse.

Then find the lines of fire P *c* and M *e*, which must pass 2′ above the parapets D C and E F, in order that the shot may clear the heads of men standing on the banquettes. The height of the traverse is determined by that line of fire which gives the greatest relief.

For the first line of fire P *c*, plant at the point L a pole 8′ high; measure on the pole D C of the profile of the parapet, C *c* equal to

2′; the visual ray passing through the points P and *c* will be the line of fire sought.

The other line of fire may be determined in a similar manner, or thus:—From the point *f*, 6′ below E, find a tangent to the dangerous ground at K; from the point *b*, where the visual ray *f* K intersects the central line A B of the traverse, measure up 8′, to find the height of the vertical A *b*.

Having thus found the relief of the traverse required to cover the widest part of the work, and its command over the parapets being known for that part, let the same command be preserved throughout.

387. **Approximate Height when Time Presses.**—These constructions, though simple, require some time. When time does not permit their employment, make the traverse one yard higher than the parapet, and the work will, in most cases, be perfectly covered.

PROFILING.

388. **Definition.**—Before breaking ground it is advisable to set up on each face two or more skeleton frames, showing the outline of the parapet, and called profiles.

389. **Practical Method.**—The height of the interior crest at the angles of the work and at intervals of 20 or 30 yards along the faces having been marked, as described under the head of defilading, lines are traced through the points selected for that purpose, perpendicular to the direction of the interior crest. The horizontal distances for the thickness of the parapet, bases of the slopes, etc., are set off on these lines, and stout pickets driven at the points of division. (Fig. 135.) Strips of pine (2½ inches by ¾ inch) are nailed vertically to the pickets marking the banquette, interior and exterior crests; and the heights of these crests respectively marked on the strips. The

outline of the parapet is shown by connecting the uprights by other strips which are nailed to them.

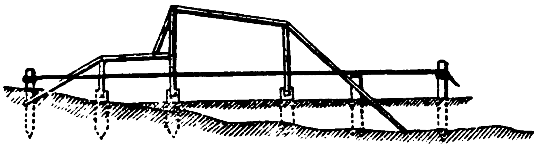

Fig. 135.—Profile of Slats.

390. **Modification on Undulating Ground.**—If the ground is undulating, the measurement of the horizontal distances may be facilitated by stretching a cord horizontal, as shown in the figure.

391. **Oblique Profiles at Angles.**—In addition to the perpendicular profiles, the intersections of the various faces at angles may be shown by oblique profiles. The perpendicular profiles must first be set up, and then the verticals of the oblique profiles driven at the intersections of the lines joining the corresponding verticals of the perpendicular profiles. The cross battens are then nailed at the required heights.

REVETMENTS.

392. **Revetments of Siege Batteries applicable.**—The revetments described under the head of Siege-Batteries, p. 139, are all applicable to Field Works, but, as the latter are usually constructed with more deliberation and are expected to remain serviceable for a longer period than siege batteries, there is a difference in the relative value of the revetments.

393. **Sod Revetment.**—In Field Works the sod revetment is superior to almost any other, on account of its yielding no splinters and its durability when carefully attended to. Should the grass roots be killed by a long drought, the wall may be

restored by applying horizontally an iron toothed rake to the face of the interior slopes, and by sprinkling grass seed on the abraded surface.

394. **Vertical Post Revetment.**—One of the most durable revetments, and one that was generally employed in the Defences of Washington,* during the war of the rebellion, when suitable timber could be procured, is a revetment of vertical posts. This consists of posts from 4 to 6 inches in diameter, of oak, chestnut, or cedar, cut into lengths of $5\frac{1}{2}$ feet, and set with a slope of 6 upon 1 in close contact in a trench 2′ deep at the foot of the breast-height. (Fig. 136.) The posts are sawed off 16″ below the crest, and shaped to receive a horizontal capping piece of 6″ timber, hewed or sawed to a half round. Anchor ties are dovetailed into the capping piece A and anchor log B.

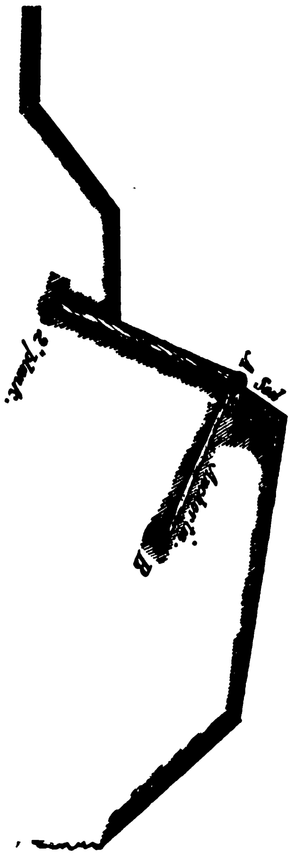

Fig. 136.—Vertical Post Revetment.

MAGAZINES.

395. **Siege Battery Magazines not applicable to Semi-permanent Works.**—The magazines described on p. 164

* See Gen. Barnard's report on the "Defences of Washington."

are of a temporary character, and are applicable to Field Works only when the latter are themselves of a similar temporary nature. They are not capable of securing ammunition against moisture for a long period, nor will the light framework of the interior long bear the weight of the superincumbent earth. Magazines of greater durability and more perfectly secured from moisture are here described.*

396. **Level of Floor.**—The floor should be placed as low as is consistent with good drainage, unless the magazine is to serve the purpose of a traverse.

397. **Dimensions.**—A convenient width is 12′, this width being adapted to the storage of powder barrels in three rows. The height should be about 6′ 6″. The length will depend upon the magazine space required.

398. **Air Chamber.**—An air-chamber should be provided around the magazine, and connected by means of ventilating

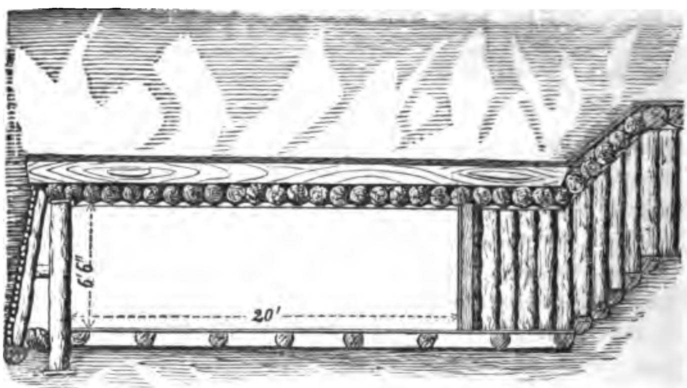

Fig. 137.—MAGAZINE.

pipes with the external air. Common earthen drain-pipes, 4″ in diameter, are convenient for the latter. There should be

* See General Barnard's "Defences of Washington."

one or two elbows in the pipe to prevent the ready transmission of sparks.

399. **Inside Lining where Timber is Plenty.**—Figure 137 shows a longitudinal, and Figure 138 a cross section of a magazine constructed in a semi-permanent work, where timber is plenty. The walls consist of a row of posts 8′ 6″ long and

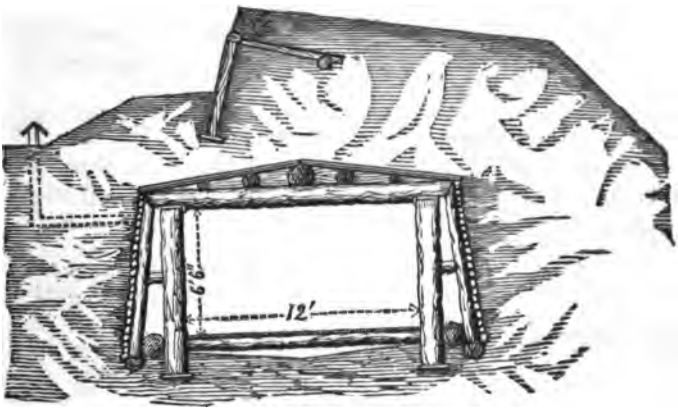

Fig. 138.—Magazine. Section.

not less than 1′ in diameter, placed vertical and in close contact with each other. They rest at bottom upon a 2″ plank placed 2′ below the level of the floor. The row is capped at top by a 2″ plank spiked to each post. A strip of 2″ plank, 4″ wide, is spiked on to the inside of the walls, its upper edge being flush with the top of the capping plank.

The roof-logs are 15′ long and not less than 12″ in diameter. They are hewn so as to lie in sufficiently close contact to retain the earth covering. A notch about 3″ deep is cut at each end, having the shoulder on the interior square, so as to fit on to the capping of the side walls, and thus resist the pressure caused by the earth outside. They are laid in juxtaposition, spanning the interval between the side walls, and

projecting about 6″ beyond them. The ends are sawed off obliquely, as shown in Figure 138.

Against these projecting ends are placed, at intervals of 3′, inclined posts, about 8 feet long and 6 or 8 inches in diameter, resting at the base upon a log hewn to a half round. These posts are kept out from the wall at bottom by a 12″ log lying horizontal.

Behind these inclined supports a revetment of small poles, from 2 to 4 inches in diameter, is placed horizontal, and carried up uniformly as the earth is replaced on the outside.

The flooring is laid transversely on sleepers, as shown in the drawing.

400. **Water-proof Roofing.**—Over the roof-logs, and along the longitudinal centre of the roof, is placed a log not less than 12″ in diameter, running the entire length of the magazine. Parallel to this are placed smaller logs of varying diameters, decreasing from the centre to the sides, so as to give a pitch of 1 on 4. These logs, or purlins, are 2½ feet apart from centre to centre.

Earth is then thrown on and rammed, until it is flush with the upper surface of the purlins.

A course of 1″ boards, (of oak or other hard, durable wood) tongued and grooved, is nailed to the purlins, having first been coated on the under side with a composition, applied while hot, of coal tar and resin boiled together. As the joints are driven home, they are flushed with a heavier composition of coal tar, resin, and sand. The upper side of this course is then thickly coated with the hot composition, after which another course of 1″ boards (pine will answer) is nailed to the first course. This roofing must be laid with great care. The second course of boards is laid simultaneously with the application of the hot composition to the upper side of the first course. A strip of the latter, about 1′ wide, is covered with the composition applied with a swab or mop of old canvas; a board of the second

course is immediately laid, being worked into the composition by two or three longitudinal motions under pressure of the hands of the workmen.

After the second course is nailed down, another coating of the composition is applied, covering every portion of the surface and flushing the joints. Two or three inches of fine, clean sand is then thrown on, followed by about 2′ of clay, applied in layers from 6 to 8 inches thick, and very thoroughly rammed. The remainder of the earth covering is then thrown on and rammed, and the slopes on the outside are sodded.

401. **Inside Lining where Timber is not Plenty.**—Figure 139 shows the cross section of a magazine constructed

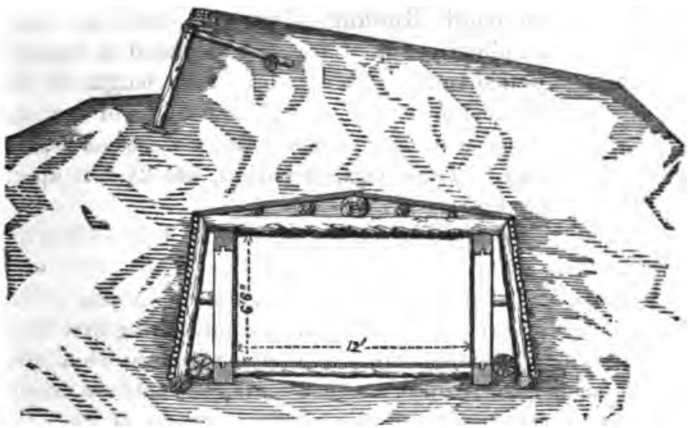

Fig. 139.—Magazine. Section.

in a locality where timber must be economized. The essential difference between it and the one already described, is in the construction of the inner walls. Instead of a row of vertical posts, these are hewn timber frames—consisting of groundsill, cap, and posts placed at intervals of 4′,—lined with 1½ inch planks. The groundsill is hewn on the upper and lower sides to a thickness of 12″. The cap is hewn to 12″ square. The

length of groundsill and cap depends on the length of the magazine. The posts are of 12″ timber, 6′ 3″ long, with a tenon at each end 3″ long and 4 inches by 2½ inches in cross section, leaving a length between shoulders of 5′ 9″. They are hewn on the inside, to give a plane surface on which to nail the lining. The tenons fit into corresponding mortises, 4′ apart from centre to centre, in groundsill and cap.

When these framed side walls are placed in position, the further construction of the magazine is identical with that already described.

402. **Kind of Wood employed.**—In both kinds of magazine, wood of a strong and durable character should be employed. Oak and chestnut are the best.

403. **White-washing.**—The magazine should be thoroughly whitewashed in the interior, both to light it and to purify the air.

BOMB-PROOFS.

404. **Interior Lining when Timber is not Plenty.**—Figure 140 shows the cross section of a bomb-proof constructed in a locality where timber must be economized. The interior walls are similar to those described for magazines, par. 401, consisting of longitudinal bents lined with boards. The ground and cap sills are hewn to 12″ square, and mortised to receive the post tenons at points 4′ apart from centre to centre. The rear posts are hewn on both sides to a thickness of 12″, and have tenons cut at both ends, 3″ long, and 4 inches by 2½ inches in cross section. They are 9′ long from shoulder to shoulder. The front posts are hewn on the inside only, have tenons similar to those of the rear posts, and are 7′ long between shoulders. These longitudinal bents are placed 12′ apart in the clear, and when they are secured in position, the roof logs are laid as prescribed in par. 399.

The roof-logs should be not less than 12″ in diameter, and are alternately 17½ feet and 25 feet long. They all project 3′ beyond the rear bent, and the longer ones also project about 8′ beyond the front one. The rear projection forms a base for a banquette, from which a musketry fire can be delivered over the superior slope of the bomb-proof. The front projection allows the structure to be anchored into the mass of earth in front, and thus resist the pressure from this mass, which comes on only one side of the structure. For this purpose the projecting ends are securely anchored to a longitudinal log held in position by vertical posts, the anchor log being sufficiently covered with earth to protect it from injury by an enemy's shot.

The interior is lined with inch boards, and the rear wall is faced on the outside with ordinary clapboarding.

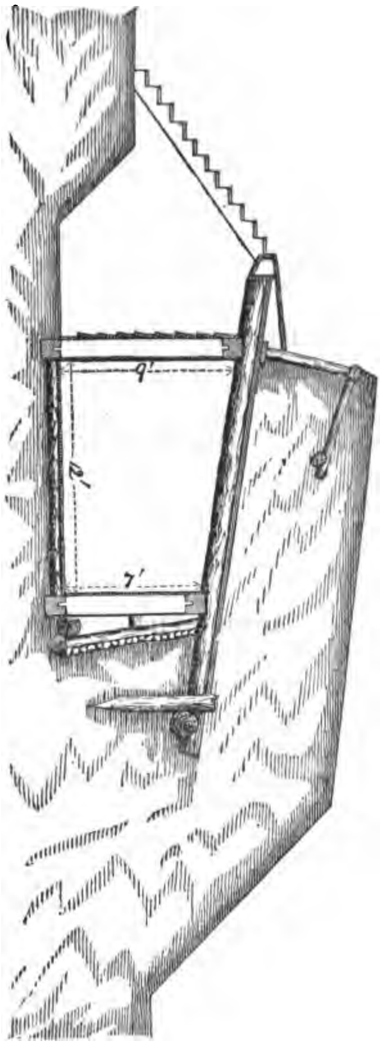

Fig. 140.—Bomb-proof.

405. **Roofing and Air-Chamber.**—The water-proof roofing is similar to that described for magazines, par. 400, as is also the air chamber on those sides brought in contact with the earth covering, par. 399.

406. **Lining when Timber is Plenty.**—When timber is plenty, the walls may be constructed of vertical posts in juxtaposition as described in par. 399.

407. **Level of Floor and Rear Area.**—The floor is usually sunk 3 or 4 feet below the general level of the terre-plein. An area is excavated in the rear, on a level with the floor, from 4 to 6 feet wide. Slopes of $\frac{1}{1}$ or $\frac{2}{3}$ connect it with the terre-plein.

408. **Thickness of Earth Covering.**—The earth covering must be not less than 8′ thick, measured from the ends of the roof-logs on a line rising therefrom with a vertical angle of 30°.

409. **Location.**—Bomb-proofs should usually be made to subserve the purpose of traverses, or to close the gorge of works which would otherwise be open at rear. In the latter case the rear wall should be built of vertical logs in juxtaposition, and this wall should be loop-holed.

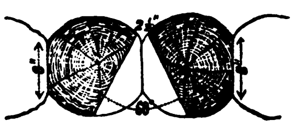

Fig. 141.—Plan.

410. **Loop-holes.**—Figures 141 to 144 show the plan, section, and interior and exterior elevations of loop-holes in vertical logs.

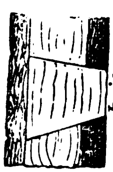

Fig. 142—Section.

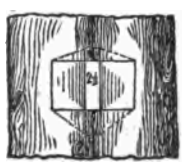

Fig. 143.—Interior Elevation.

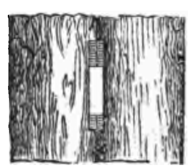

Fig. 144.—Exterior Elevation.

SECTION XV.—INTRENCHMENTS.

REMARKS—SHELTER TRENCHES—RIFLE TRENCHES.

REMARKS.

411. **Use of Intrenchments General.**—The constant use of intrenchments in positions and on the field of battle, in recent wars, has removed all occasion for argument as to their necessity. In our service, when near the enemy, the first duty of the troops, upon halting after a march, is to intrench themselves. Experienced soldiers do this before eating or resting, and they do it without urging. The difficulty is to get them to wait until a proper line of defence has been selected for them.

412. **Rifle Trenches.**—Should the ground be occupied for a prolonged period, these hasty defences are constantly strengthened until they become what are called Rifle Trenches. These somewhat resemble the parallels in a siege, before completion, and are often strengthened by redoubts, or other enclosed works, established at suitable points, thus forming regular "Intrenched Lines," as described in works on Field Fortification.

413. **Necessity with Line Officers of a knowledge of Laying Out Intrenchments.**—It is important that the original line of trenches should be selected with care, in order to economize the labor of the troops and avoid unnecessarily

cutting up the ground. Engineer officers are not always at hand to point out the proper line. It is the duty therefore of every line officer to prepare himself by study and practice to choose positions and lay out intrenchments, availing himself of all natural advantages of the ground.

414. **Shelter Trenches.**—This use of hasty intrenchments is not limited to defensive positions' properly so called. It is carried on to the battle-field itself. Troops who are to remain in position for a single hour, in presence of the enemy, must have some cover. Such cover is necessarily of an incomplete character, and has received the name of Shelter Trenches.

SHELTER TRENCHES.

415. **General Conditions.**—There should be ready means of getting in and out of these trenches, both to the front and rear; it is also desirable that they should not offer any great impediment to a forward movement, and that troops should be able to march straight over them when necessary. At every 100 yards or so, to enable guns, cavalry, &c., to pass, slight ramps should be formed, or intervals left in the trenches, which may at these places be made to overlap.

416. **Tools.**—It is not yet decided in our service to require every soldier to carry an intrenching tool, though the force of Napoleon's remark that "there are five things from which the soldier must never be separated—his gun, his ammunition, his knapsack, his rations for four days, and an intrenching tool," is, as regards the last item, becoming every day more distinctly felt. Tools must therefore be distributed in a manner similar to that before described, par. 160, 162, except that each man receives only one tool instead of two. A good proportion of the two kinds will be one pick to every two shovels. The bat-

talion is then formed, every third file being provided with picks and the remainder with shovels.

417. **Tracing.**—To trace the line, an officer from each battalion, assisted by a non-commissioned officer, places as markers on the edge of the excavation towards the enemy some drummers or other soldiers, about 40 yards apart. A line is then cut with a pickaxe from one marker to the other. Another line, marking the inner edge of the trench, is then traced in the same way, about 4′ from the first, more or less according to the profile.

418. **Posting the Troops for Work.**—The battalion is halted four paces from the trench to be dug, the ranks are opened, arms grounded, and knapsacks unslung. The men in the rear rank lie down. The front rank advance with their tools, and each group of three takes a piece of ground 5′ 6″ long (the space occupied by three men in the ranks). The man with the pick places himself between and behind the others who have shovels.*

If the work should last longer than 20 minutes the rear rank will relieve the front.

This method of posting the troops for work will afford cover in the least time. The men are apt to injure each other, however, with their tools, and if time can be spared they will work to better advantage by being posted at greater intervals. One half the front rank distributed over the front of the battalion will furnish cover for the whole in about half an hour.

419. **Profiles, Minimum.**—The most rapid way for infantry to obtain cover is by the excavation of a trench 2′ wide and 1½ feet deep; the earth is thrown to the front so as to form a parapet about 1½ feet high, the interior slope being built up as

* See Col. Brialmont's "Fortification Improvisée."

steep as possible with sods, clods, etc. (Fig. 145.) Such a trench can be executed by men with their accoutrements on, distributed at about 4′ intervals, in from 10 to 20 minutes.

Fig. 145.

This is the smallest that is of any use, and will afford cover to two ranks, one kneeling in the trench, and one lying in rear of it.

420. **To Cover Double Rank, Kneeling and Lying Down.**—The above trench can be widened out to 4′ in from 10 to 20 minutes more, and will then afford cover for a double rank kneeling. (Fig. 146.) This may be considered an effective trench for occupation for a limited time, but as the

Fig. 146.

troops in it would be in a constrained position, it would be desirable, should still more time be available, to widen it out to a total breadth of 7′ (Fig. 147), which would require about 20 minutes more.

Fig. 147

421. **Height of Parapet.**—The height of the parapet given in the profiles is that over which men can fire kneeling; the parts between the positions the men would occupy may be made higher to afford better cover.

422. **Boughs of Trees.**—Boughs of trees stuck in on the top of the parapet would further conceal the defenders without impeding their fire.

423. **Obstacles.**—Should there be no objection to placing impediments in the way of a forward movement, obstacles may be formed 100 yards or so in advance of the trench.

RIFLE TRENCHES.

424. **Tracing, Formation of Working Parties, &c.**—When rifle trenches are constructed with some deliberation, the tracing, distribution of tools, and the formation of working parties, may be the same as described in paragraphs 150, 155, 160, 162, for the construction of a parallel by simple trench, with some slight modifications readily suggesting themselves to suit the different circumstances of the case. The parties are posted by merely forming line in single rank and then extending intervals.

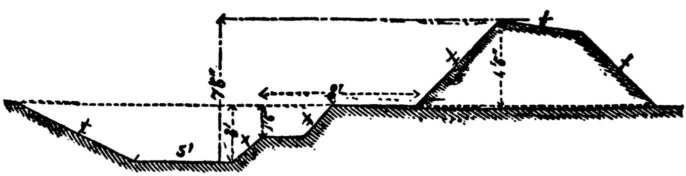

Fig. 148.—Covered Way for Infantry.

425. **Profiles.**—The profile may be made as shown in Fig. 148 when the trench is to act as a covered way for infantry, as

in Fig. 149, when a covered way for artillery, or as in Fig. 150, when it is to serve merely the purpose of concealing infantry.

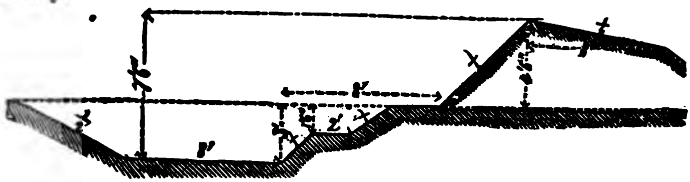

Fig. 149.—Covered Way for Artillery.

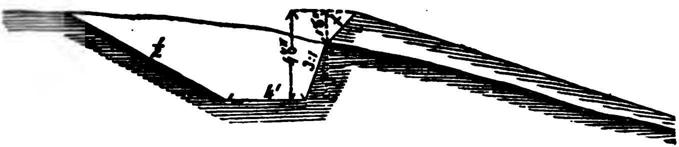

Fig. 150.—Rifle Trenches.

426. **Revetment sometimes Employed.**—In wooded regions a revetment of the interior slope may be formed of logs laid one over the other, using tie pieces about 4′ long, which are notched on two sides near the end, to fit into corresponding notches made in the logs above and below. The horizontal logs are thus roughly connected and tied into the parapet, the tie pieces projecting about 3′ into the earth, and 1′ toward the inside to facilitate mounting the parapet.

427. **Loop-holes.**—Loop-holes should be constructed along the parapet, to shelter the men in firing.

With Sand-bags.—They can be made with 4 sand-bags well filled and beaten, two placed splaying inwards (Fig. 151), about 10″ apart at the mouth, with an opening of 3″ to the front for the muzzle of the rifle; the other two sand-bags are laid on top of these (Fig. 152), supported if necessary by pieces of wood.

Fig. 151.

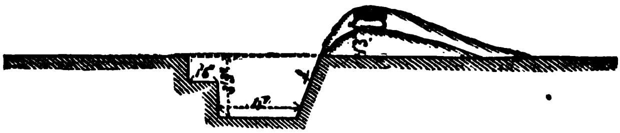

Fig. 152.—Rifle Trenches.

428. **With Boards.**—A loop hole of boards is shown in Figures 153 and 154.

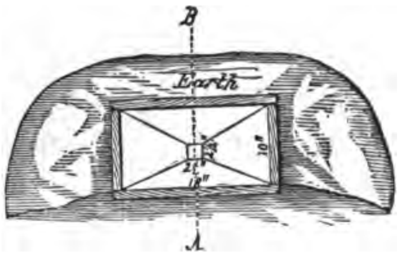

Fig. 153.

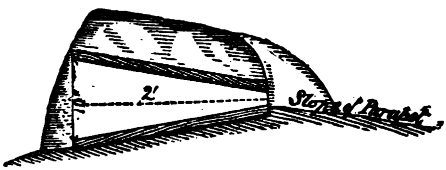

Fig. 154.—Section on *a b*, Fig. 153.

429. **With Logs.**—A log from 10 to 14 inches in diameter, hewn on two sides, is sometimes laid on top of the parapet, notches being cut in the lower side about 6′ apart. These notches taper towards the outside, as in the board loop-hole. Where there is much sharp-shooting, the mouth of the loop-hole is covered with a plate of boiler iron, 8 or 10 inches square, with a hole in the centre a little larger than the musket barrel. These plates are spiked to the front side of the log.

430. **Branches to Check a Successful Enemy.**—In long lines of rifle trenches, branches should be run back, at intervals of five or six hundred yards, in a direction nearly perpendicular to the main line, to shut off the enemy in case of his forcing his way through, and prevent him from turning the whole line by his advantage at a single point. The length of any two consecutive branches taken together should be about equal to the interval between them.

SECTION XVI.—OBSTACLES.

ABATIS—SLASHING — PALISADES — FRAISE — TROUS-DE-LOUP — WIRE ENTANGLEMENT—CHEVAUX-DE-FRISE—CROW'S-FEET, ETC.—BARRICADES—INUNDATIONS—FOUGASSES—TORPEDOES—STOCKADES.

ABATIS.

431. **Construction of Abatis.**—One of the be stobstacles that ĉan be made is an abatis, formed of stout limbs of trees, 12 to 15 feet long, laid as close together as possible, with the branches towards the enemy. The abatis should be at least 5′ high, the large end of each limb being secured to the ground by a crotchet picket. (Fig. 155.) The butts may be partly imbedded, or they may be secured by logs of timber laid across several butts. The small branches are chopped off, and the large ones are pointed.

432. **Position.**—The abatis should be placed about 50 yards in front of the ditch. If possible a second line should be established 50 yards further to the front.

Sometimes they are placed in the ditch of the work in an upright position against the counterscarp.

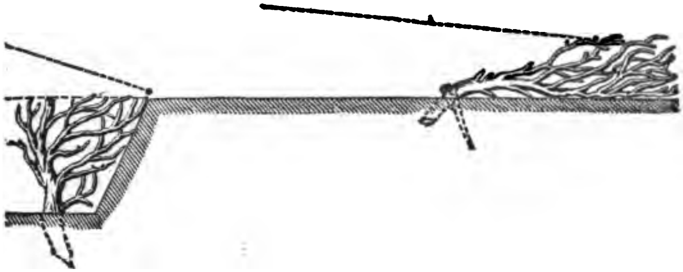

Fig. 155.—Abatis.

The glacis in front of them, usually recommended to protect them from the enemy's artillery fire, may be omitted, as experience has shown that the effect of a direct fire of artillery upon them is very slight.

433. **Conditions of Employment.**—The construction of abatis should not be attempted unless the trees grow near at hand. Hard and tough woods are the best, pine being the worst. The timber should not be felled long before it is required.

SLASHING.

434. **Slashing, how made.**—An excellent obstacle, which finds its application in forests, is a slashing. It is formed by felling trees so that they will fall towards the enemy.

Defects.—In dry weather it is liable to be set on fire, particularly if it has been long cut.

PALISADES.

435. **Description of Palisades.**—A palisading is a row of stout stakes planted in the ground, in either a vertical or inclined position. The stakes or palisades are about 10′ long,

pointed at top, and may be made of either split or round stuff, the latter being the best. They should be not less than 4″, and not more than 8″, in diameter. If the timber is large and a saw-mill is at hand, they may be ripped into a triangular form, each side of the triangle being 8″ long.

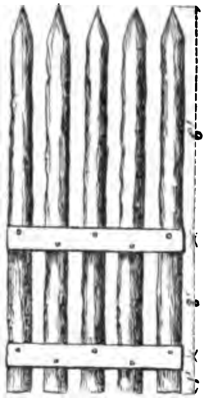

Fig. 156.

436. **Panels of Palisading.**—The palisades are connected together by two riband pieces of 2″ plank placed horizontal, one about 1′ from the bottom, and the other about 4′. Four or five palisades are thus connected, intervals of 4″ being left between them, thus forming a panel. (Fig. 156.)

437. **To plant inclined Palisading.**—To plant the palisades in an inclined position, a trench is excavated 3′ deep and 2′ 6″ wide. The panels having been placed in a row, the earth is thrown back into the trench and rammed. (Fig. 157.) The riband pieces are always placed on the side towards the enemy,

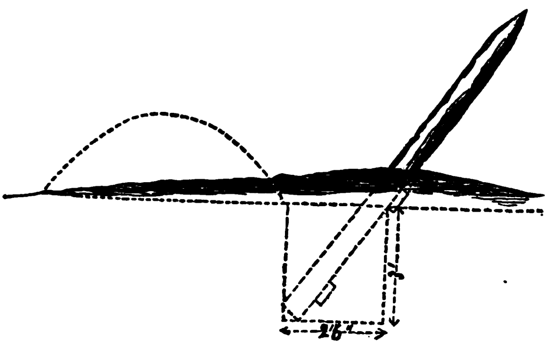

Fig. 157.

as the effect of a shot striking the palisading will thus be least extended.

438. **Vertical Palisading.**—Vertical palisading is planted in the same manner, except that the trench is made as narrow as practicable.

439. **Position.**—Palisading may be placed at the foot of the counterscarp, or in front of the ditch. In the latter case it should be about fifty yards from the ditch.

FRAISES.

440. **Fraises.**—Fraises are palisades placed horizontally or nearly so in the slope of the scarp or counterscarp. (Fig. 158.) If in the former, they should be inclined slightly downward, to allow shells to roll over into the ditch, and should have their points not less than 7′ above the bottom of the ditch, that they may not assist an enemy in climbing up. The fraises should project about 5′ beyond the scarp.

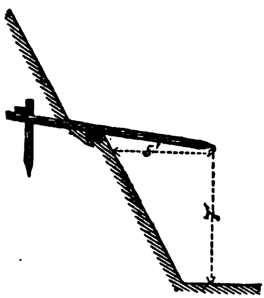

Fig. 158.

Riband Pieces.—The riband pieces are on opposite sides, the one nearest the scarp being below, and the other above, the fraises.

TROUS-DE-LOUP.

441. **Trous-de-loup.**—Trous-de-loup, or military pits, are excavations in the shape of an inverted cone or square pyramid, with a pointed stake at bottom. A number of rows form a good obstacle, particularly against cavalry.

442. **Position.**—They are usually placed beyond the counterscarp, and principally opposite the salient angles.

443. **Two Kinds.**—They are of two descriptions, deep and shallow. The first should be so deep that when a man has fallen in, he may not be able to use it as a rifle pit, and the second so shallow as not to afford cover to skirmishers.

444. **Construction of Deep Pits.**—The deep pit is made 6′ in diameter at the top, and 1′ at the bottom, the depth varying from 6 to 10 feet. A stake is driven in the centre, with its top flush with the ground. They are usually placed in three rows, the pits being 10′ from centre to centre, and the ex-

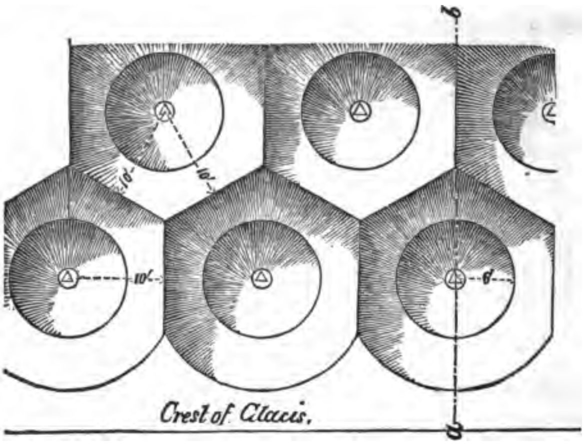

Fig. 159.—Deep Military Pits.

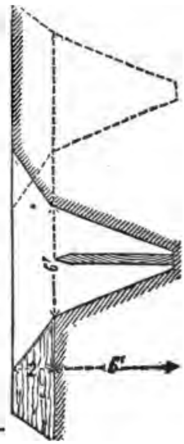

Fig. 160.—Section on *a b*.

cavated earth being heaped up on the space between them. (Figs. 159 and 160.) One man can construct two per day in easy soil.

445. **Construction of Shallow Pits.**—The shallow pits are shaped like inverted pyramids, 3′ square, and not more than 2′ 6″ deep. They are placed in rows touching each other, as shown in Fig. 161. Five rows are usually made, and the

earth excavated is thrown to the front to form a glacis. The row next the counterscarp is first formed, so that the earth excavated from any one pit may not have to be thrown over those

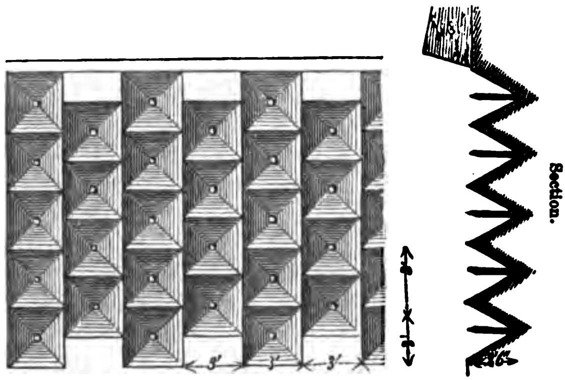

Fig. 161.—Military Pits.

previously excavated. A pointed stake should be placed in each hole, with its top flush with the ground line. One man can excavate ten pits per day in easy soil.

WIRE ENTANGLEMENT.

446. **Construction.**—For wire entanglement, stout stakes are driven into the ground about 7′ apart, in three or more rows, arranged checkerwise, and their heads connected by strong wires crossing diagonally, twisted round the heads of the stakes about 1′ or 18″ above the ground.

447. **Advantages.**—This obstacle is rapidly prepared, little injured by artillery fire, and is impassable by cavalry.

CHEVAUX-DE-FRISE.

448. **Construction.**—Figure 162 shows a cheval-de-frise. It consists of a horizontal piece of square timber, about 10′ long and 6″ square, with pointed poles driven through the timber at

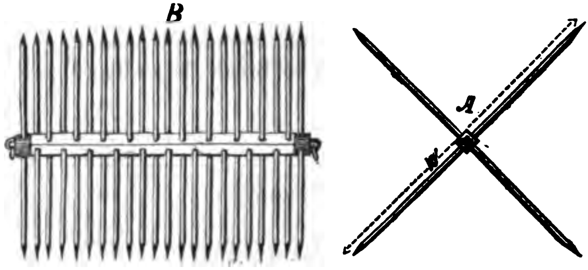

Fig. 162.—Section A and Elevation B of Cheval-de-Frise.

right angles to each other and 5″ apart. The pointed poles or lances should be so strong that a man cannot break them. They may be made 2½ inches in diameter. The chevaux-de-frise must be securely bolted together.

449. **Disadvantages.**—As chevaux-de-frise can be easily removed, they do not form a good obstacle against infantry. They are very troublesome to make, and, though forming a good defence against cavalry, can generally be replaced by some obstacle equally effective and less troublesome.

CROW'S-FEET, ETC.

450. **Crow's Feet.**—Crow's-feet are formed of four stout spikes 2½ or 3 inches long, welded together at their heads in such a manner that in whatever position they may be there will always be one point uppermost. (Fig. 163.) They are very useful as impediments against cavalry, and may also be placed in fords, etc.

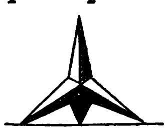

Fig. 163.—Crow's-foot.

451. **Boards with Nails driven through them.**—Boards with sharp nails driven through them may supply the place of crow's-feet. The boards are imbedded in the ground, with the sharp points projecting above it.

452. **Harrows, &c.**—On the glacis harrows may be buried with the spikes exposed, or broken wheels and large rough stones may be strewed about to break the order of the assailants.

BARRICADES.

453. **Construction of Barricades.**—Barricades may be made of almost anything. Loaded carts sunk up to the axles, filled casks, trunks of trees well secured together, furniture, heaps of stones, rubbish, iron railings, bales of goods, &c., can all be made available. (Fig. 164.) A barricade can be made

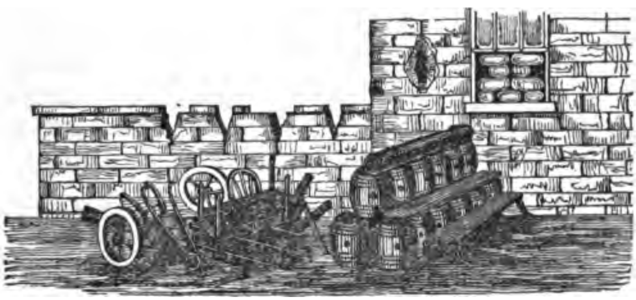

Fig. 164.—Barricades.

with timbers laid across one another, forming square or oblong cribs, the interiors being filled with stones. A line of wagons drawn across the street, with the wheels on one side taken off, will be a sufficient impediment to cavalry.

Banquettes should be formed, and the barricades flanked by

loop-holes made in adjacent houses. (Fig. 165.) A communication should be made from house to house, on each side

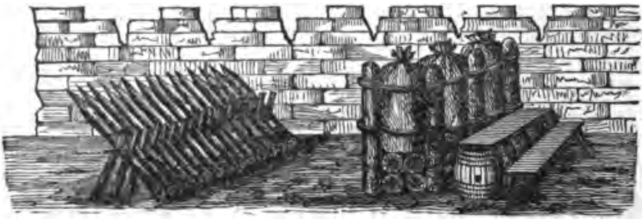

Fig. 165.—Barricades.

of the street, to allow of firing on an advancing column. If several barricades are made in a street, the means of retreat through them must be preserved.

INUNDATIONS.

454. **Inundations.**—Inundations, formed by damming back a shallow water-course so as to make it overflow its valley, form good obstacles, even if fordable. In the latter case they should have trous-de-loup and trenches dug irregularly over the surface of the ground, and crow's-feet, harrows, &c., may be scattered about.

455. **Construction of Dam.**—In making an inundation the embankment on each side of the stream should be finished first. The chief difficulty is always encountered when constructing the part over the bed of the stream, which should be continued as rapidly as possible, as when once the stream is dammed up, the dam must keep pace with the rise of the water. Materials should be collected below the dam, and on each side of the stream, and as large a working party employed as can work together. A bank of earth is first made across the opening between the two finished portions of the dam, to enable the foundations of the remainder to be put in.

456. **Materials for Dam.**—The dam may be made of good binding earth, or of crib-work of logs filled in with stone, gravel, and earth (Fig. 166), or of successive layers of fascines

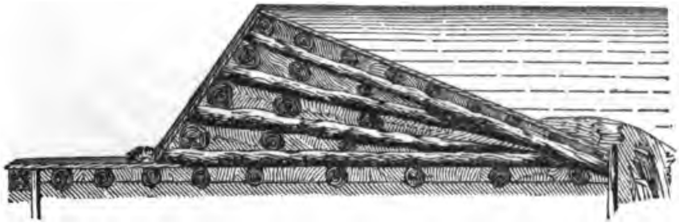

Fig. 166.—Waste Weir on Soft Soil.

and gravel. In the latter two cases, a lining of puddled clay* should be built up on the upper side. When the dam is built of earth the soil should be impervious to water, or, if it be not, a wall of puddled clay should be constructed inside the dam. The earth should be well rammed in layers not more than a foot thick.

457. **Profile of Dam.**—The thickness of the dam at top may be made equal to the depth of water retained. The slope of the upstream side is usually made $\frac{1}{2}$, and that of the lower side the natural slope of the earth. When exposed to artillery, the top should be made thick enough to resist the fire.

458. **Waste Weir.**—Unless the surface of an earthen dam be protected, it will soon be washed away by water flowing over it. A waste weir must therefore be made, large enough to carry off all the water of the stream. A channel for a waste weir should be cut through the solid ground, clear of the dam if possible, but if not it must be formed in the dam itself. It may be made of fascines if planks and timber cannot

* Clay is puddled by being well kneaded with a small quantity of water.

be procured. The bank near a weir must be constructed with extra care, and should be well revetted; this revetment should extend beyond the foot of the dam on the lower side, so as to protect it from the rush of water over the weir. A double layer of fascines securely picketed forms a good revetment. The surface of the weir should be two or three feet below the top of the dam, according to the liability to floods.

459. **Sluice Gates.**—Sluice gates are occasionally required to drain the inundations. They are made like the sluices of a mill-dam.

460. **Bridge used for Dam.**—An inundation may sometimes be formed by damming up the arches of a bridge.

FOUGASSES.

461. **Definition.**—Fougasses are a kind of mine, which on being exploded throw forward the superincumbent material, whether it be shells, stones, or bricks, scattering it over a large surface.

462. **Position.**—They should be placed in front of salients and weak places, and should not be too near the counterscarp, for fear of injuring it.

463. **Application.**—An objection to their use is the difficulty of springing them at the proper moment. Used in connection with some other obstacle, as abatis or palisades, they can be sprung while the enemy is detained in front of them, and might thus prove useful, though a good volley or two of musketry would probably answer the purpose better. Their use is limited to the exceptional case when the enemy is likely to expose himself at close range in large masses.

464. **Shell Fougasse.**—A shell fougasse is simply a box buried in the ground, the lower part filled with powder, and the upper part with shells.

465. **Stone Fougasse.**—For a stone fougasse, an excavation is made in the form of the frustrum of a cone or pyramid

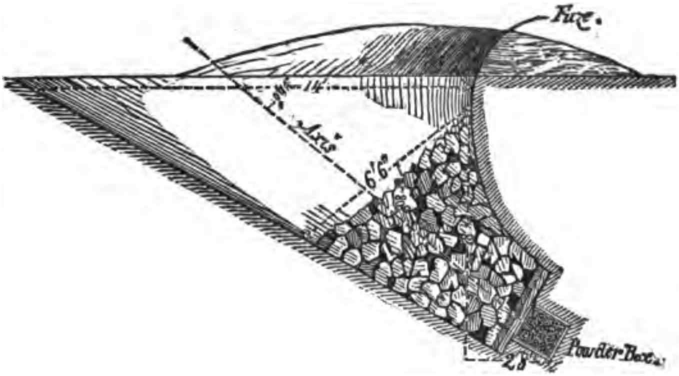

Fig. 167.—FOUGASSE. Section.

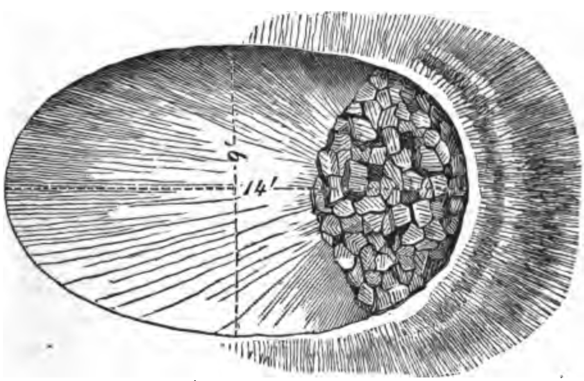

Fig. 168—FOUGASSE. Plan.

(Figs. 167 and 168), a box of powder is placed in a recess at the bottom, and on the box a wooden platform three or four

inches thick, on which the stones, &c., are piled. The axis should be inclined at about 40° with the horizon, and the top and bottom of the pile at an angle of about 12° with the axis. The line of least resistance must be so arranged, by placing earth over the fougasse, that the powder acts in the direction of the axis, and not vertically. The fuze is carried up from the powder box, along the side of the excavation, to the rear.

TORPEDOES.

466. **Torpedoes.**—A torpedo is a case loaded with powder, buried in the ground (when on land), and so arranged as to be exploded by electricity, or by the weight of a person stepping upon it. In the latter case, it is called a sensitive torpedo. It is a valuable obstruction from its effects, both physical and moral, but especially the latter.

467. **Disadvantages of the Two Kinds.**—The sensitive torpedo is a dangerous weapon to use, as casualties will constantly occur from accidental explosions, both during and after the planting. The disadvantage of exploding by electricity lies in the difficulty of exploding at the proper moment.

468. **Methods of Planting and Exploding.**—The methods of laying and exploding them, which have been used in service, are crude and unsatisfactory. The following method proposed by Capt. W. R. King, Corps of Engineers, promises good results.* It will be seen that it provides against the danger of accidental explosions, by enabling the operator to sensitize the torpedo at will, thus combining the advantages of both methods of explosion.

* "Torpedoes: Their Invention and Use," by W. R. King, Capt. of Engineers and Bvt. Major, U. S. A.

469. **Case.**—"A 15" cast iron shell is, for many reasons, the most suitable case to contain the charge. It is strong, and will hence develop the full force of the charge; convenient, as two men can handle one; cheap, since defective columbiad shells may be used; and will furnish a large number of effective fragments. This number may be increased by casting or turning creases in the surface of the shell, dividing it into squares of about two inches on a side.

470. **Charge.**—The shell should be *filled*, which will require about 17 lbs. of mortar powder, when the ordinary shell 2½ inches thick is used; and 25 lbs. when they are cast but two inches in thickness, which would be advantageous if special shells were made. When gun-cotton comes into general use, it will doubtless be found better to use a 13″, or perhaps a smaller shell, in both land and marine torpedoes.

471.—**Planting.**—When time and materials are to be obtained, a flat stone *b b*, (Figs. 169 and 170) two or three feet square, should be placed under the shell, and inclined slightly

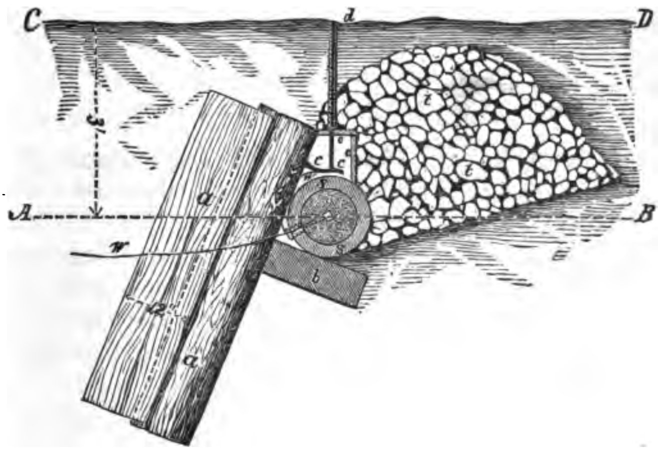

Fig. 169.—Planting Torpedoes.—Section on A B, Fig. 170.

towards the enemy, to prevent fragments from penetrating the earth, and cause as many of them as possible to be projected

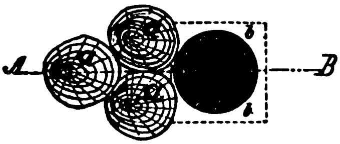

Fig. 170.—Planting Torpedoes.—Plan.

forwards and sideways; and for the same purpose, as well as to shield the parties operating the torpedoes when they are near at hand, two or three tough logs *a a a*, 10 or 12 inches in diameter, and 6 or 8 feet long, should be firmly planted, as shown in the drawing, on the side towards the work defended.

The shells should be planted in quincunx order, their centres about 3′ below the surface of the earth, and from 20 to 50 feet apart, according to the importance of the work. Like other auxiliary defences, they should be placed within effective range of the principal works."

472. **Tamping.**—"Stones, bricks, pieces of timber, lumps of clay, or bags of sand, will be found more effective projectiles, and may more easily be removed, in case removal becomes necessary, than ordinary earth; and in covering the wires, boards, rails, or straw, should be first laid over them, to prevent the insulation from being destroyed by sharp stones or damp earth, as well as to facilitate the removal or renewal of the wires. The trench containing the wire should also be so directed, if practicable, as to serve as a drain for the water which might collect over the shell and exploding apparatus.

473. **Fuze.**—This may be constructed on the principle of Beardslee's or Abel's fuze, but with the addition of another wire, making with the two already used an equilateral triangle, as shown in Fig. 171. The first two wires are conducted, parallel to each other, to the battery," care being taken to place them beyond the reach of the enemy's shells, "while the third ends near the torpedo and is attached to the connecting appa-

ratus to be described. A spark passing from a' to b', from b' to c', or from a' to c', will ignite the charge.

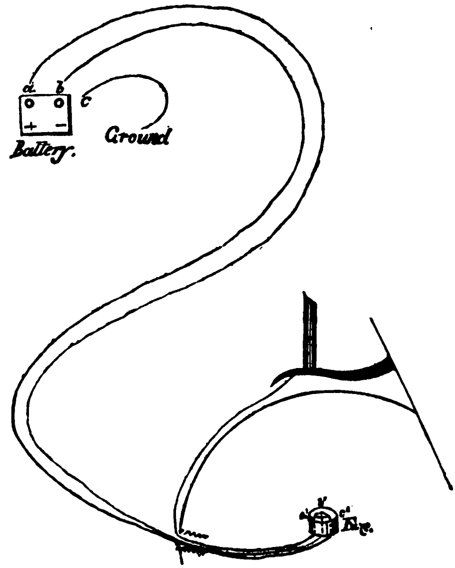

Fig 171.

474. **Connecting Apparatus.**—This consists in any simple device by means of which the end of the short wire from the fuze is connected with the surface of the shell, thus forming a circuit through the ground; this connection being determined by the pressure of the foot of a man or horse. Figure 169 shows one device for this purpose, *c c* being a small spring, insulated from the ground and attached to one of the logs a short distance above the top of the shell; *c d* a small wooden*

* Two or more standards might be used to advantage for the purpose of increasing the chances of an object coming in contact with the apparatus, or pieces of board or rails laid carelessly across the upper end of the standard would tend towards the same result.

standard resting upon the spring and reaching to the surface of the ground; and *e e* being pieces of board placed over the spring, to exclude the earth and preserve the insulation."

475. **Conducting Wires.**—"Two No. 16 copper wires, each covered with a single coating of vulcanized rubber, and two cords of tarred hemp of about the same diameter, being placed together so that the wires shall be opposite to each other, and closely wound with tarred hemp, will answer all purposes."

"In order to economize wire, it has been attempted to explode several torpedoes by a single wire, but the numerous failures which have resulted, have placed it beyond a doubt that in almost all cases likely to arise, it will be cheaper in the end, and far more reliable, to have a separate wire for each torpedo."

476. **Battery.**—The best machines for exciting the electric current are those referred to on p. 44, par. 63. In the above arrangement of wires, &c., provision has been made for passing the current through the fuze in three different directions—1st, through the wire *a* and the ground; 2d, through the wire *b* and the ground; 3d, thro' the wires *a* and *b*. The last is to be used only in case the first two both fail.

"The manner of operating the battery, in exploding land torpedoes, will be as follows: *c* being connected with the negative pole of the battery (Fig. 171), when an object is seen approaching the torpedo, put the battery in motion, and connect *a* and *b* alternately with the positive pole. In order to do this with facility, each of the wire ends might be connected with a small spring, and these springs fingered like the keys of a piano. Should the object come in contact with the connecting apparatus, a spark will pass from a' to c', or from b' to c'; if both these chances fail, connect *a* with the positive and *b*

with the negative pole of the battery, which will give a spark *a′ b′*."

STOCKADES.

477. **Stockades.**—Stockade is the name given to a close barricade of timber. (Fig. 172.) Trunks of small trees from

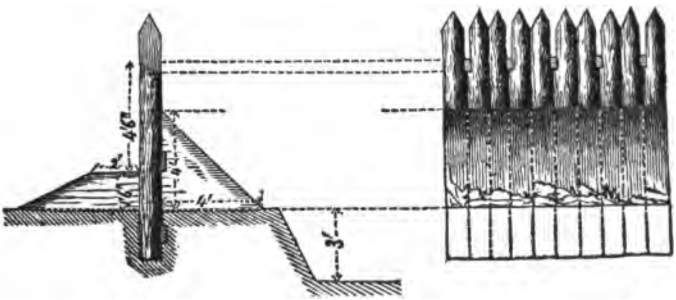

Fig. 172.—Section and Elevation of a Stockade.

9 to 15 inches in diameter, and about 12′ long, are planted in juxtaposition, being squared where they come in contact, so as to give a flat surface of about 4″ in width.

The top of the stockade should be at least 8′ above the ground. The timbers should be spiked to two or more riband pieces, to give them stability.

478. **Loop-holes.**—Loop-holes are made between two timbers, half being cut out of each. For this purpose a strip about 2′ long is cut from the top of the two timbers, in such a manner that, when placed side by side, there shall be an opening at top, between them, 8″ wide on the interior and 2½ inches wide on the exterior. The distance between the loop-holes should be 3′.

479. **Banquette.**—A banquette is thrown up on the interior, 2′ wide and 1′ 6″ high.

480. **Ditch.**—About 4′ in front of the stockade a ditch is made, the earth being thrown up against the stockade, to prevent the enemy from attempting to cut it down.

481. **Application.**—The foregoing arrangement of a stockade makes it a primary defence, which is its usual application. Should it be intended as an obstacle merely, the loop-holes and banquette may be omitted, as well as the ditch in front.

SECTION XVII.—DEFENCE OF WALLS, HEDGES, BUILDINGS, &c.

GENERAL PRINCIPLES OF DEFENCE—DEFENCE OF WALLS—DEFENCE OF HEDGES—DEFENCE OF VILLAGES—DEFENCE OF BUILDINGS.

GENERAL PRINCIPLES OF DEFENCE.

482. **Principle of Defence.**—The following are the principles to be borne in mind in forming a military post or in strengthening a position:

1*st.* To obtain cover for the men from the enemy's fire.

2*d.* To enable the troops to fire in the most advantageous manner on the ground over which the enemy must advance.

3*d.* To hinder the approach of the enemy by obstacles which, even if surmountable, shall be sufficient to break his order and to detain him for some time under fire.

4*th.* To enable the troops to pass freely from one part of the works to another, in order to concentrate on any point attacked.

5*th.* To impede the flank movements of the enemy as much as possible, and thus prevent his different parties from supporting each other effectually.

483. **Cover.**—Many existing obstacles, such as hedges and ditches, walls, &c., may be converted into good cover for troops. Perfect cover should protect not only men close to it, but also those in rear, and should not therefore be less than 6′ high. Even breastworks 4½ feet high are of great use; they may be much improved by having loop-holes formed on the top, by means of logs of wood, bags, boxes, or barrels filled with earth.

It should be borne in mind that anything which will screen the defenders from view, although not bullet proof, is of advantage.

484. **Level of Loop-holes.**—When it is possible for the enemy to approach close to the cover, as in the case of walls or stockades without ditches, the loop-holes should be either on the level of the ground, or not less than 6′ above it, so that he cannot fire through them.

DEFENCE OF WALLS.

485. **Wall 4′ High.**—A wall under 4′ in height is hardly defensible, though it would afford protection to the men behind

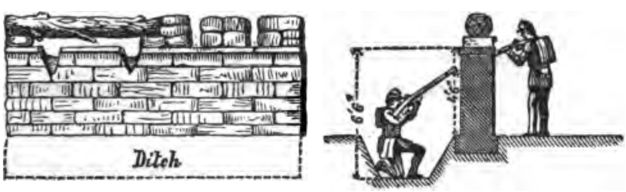

Fig. 173.

it. A wall 4′ in height may be used without any preparation as a breastwork, but if possible a ditch should be dug in front of it. Additional cover may be obtained by placing stones on the top, leaving spaces between them to fire through, or logs of trees or pieces of timber may be used. (Fig. 173.) If time admits, a trench may be formed in rear.

486. **Wall over 4½ Feet High.**—If a wall be more than 4½ feet high, but too low to admit of loop-holes being cut in it, a banquette should be formed, and excavations made in front and rear. (Fig. 174.)

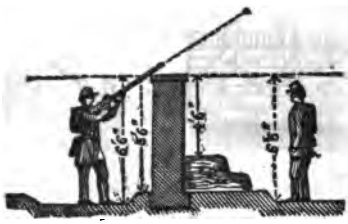

Fig. 174.

487. **Walls from 7 to 10 Feet High.**—If the wall be high enough, the upper part may be broken down, and a banquette formed of it, fissures being made to fire through, 4½ feet above the banquette, and at least 6′ above the ground (Fig.

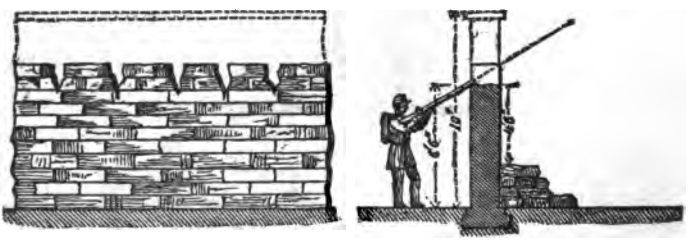

Fig. 175.

175); or loop-holes may be pierced in it 4½ feet above the ground, and a ditch dug in front, to prevent the enemy

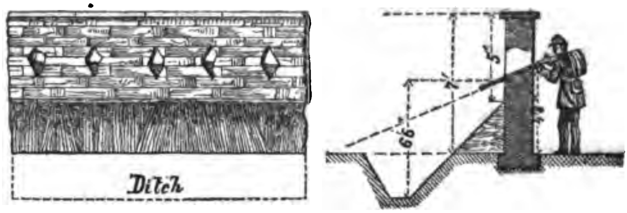

Fig. 176.

closing in and using them. (Fig. 176.) Or again, fissures may be formed in the top of the wall, and the upper parts

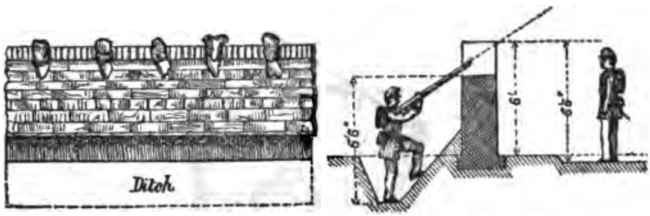

Fig. 177.

blocked up with large stones, sand-bags, &c. (Fig. 177.) Or finally it may be arranged with a banquette. (Fig. 178.)

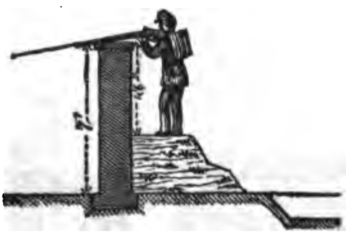

Fig. 178.

488. **Height of Loop-holes.**—It should always be borne in mind that it is better not to have the loop-holes less than 6′ above the ground, as then bullets fired through them will pass over the troops in rear.

489. **High Walls.**—With high walls, two tiers of musketry fire may be obtained by forming a banquette of woodwork, and piercing loop-holes on the level of the ground. The banquette may be supported on trestles, casks, &c., and to enable the defenders to use the lower loop-holes a trench must be made in rear 3 or 4 feet deep, and 2′ from the wall. (Fig. 179.) In

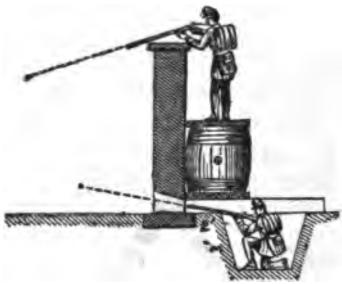

Fig. 179.

this case a ditch should not be dug in front of the wall, as it would enable the enemy to use the loop-holes.

If the wall be high enough, the lower tier of loop-holes may be at the ordinary height, and arranged with a ditch in front. (Fig. 180.)

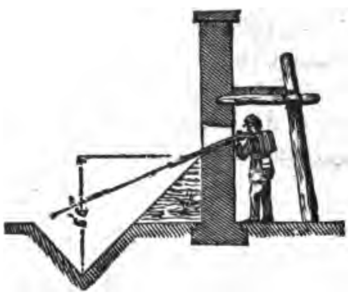

Fig. 180.

490. **Ditch in Front of a Wall.**—A ditch in front of a moderately high wall should be sufficiently deep to prevent an

enemy in it using the loop-holes or firing over the wall. To obtain the greatest width, and to keep the enemy as far off as possible, the section of the ditch should be triangular. It should be made a little distance from the wall, and the earth laid on the berm, to prevent the enemy standing on it. With a low wall however the ditch must be excavated close to it, and the earth spread about.

491. **Tambours.**—When a loop-holed wall is of great length and straight, it should be flanked. This may be done by means of a tambour or small stockade, in plan like a redan or lunette, (Fig. 181) the wall being broken through to obtain

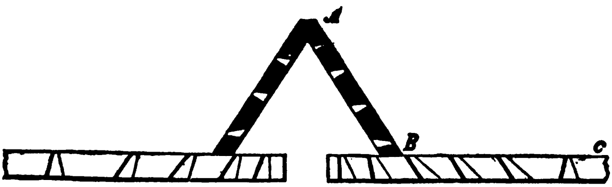

Fig. 181.—TAMBOUR.

an entrance, which should be provided with a stout door or barrier, loop-holes being made to fire through into the interior of the tambour, if forced. The salient angle should be 60°. The neighboring loop-holes in the wall should be directed so as to fire on the salient; those at the salient should be 6′ above the ground, to prevent bullets which may enter by them wounding the men at the other loop-holes.

Tambours are constructed like stockades, (par. 477) and

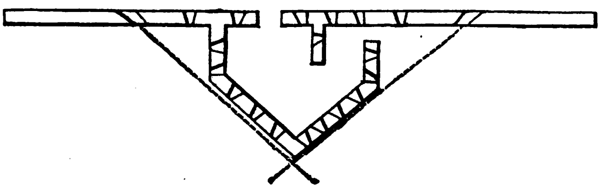

Fig. 182.—TAMBOUR.

should be treated as regards loop-holes, ditches, and trenches, as walls.

Tambours serve also to cover gates, openings being left between them and the wall, which can be closed by barriers, chevaux-de-frise, or loop-holed doors. (Fig. 182.)

DEFENCE OF HEDGES.

492. **Hedges.**—Strong hedges form one of the best obstacles that can be found, and with comparatively little labor. Weak parts should be strengthened by weaving in branches. A trench is excavated 12′ in rear of the hedge, and the earth from it laid against the hedge in the form of a parapet and banquette. (Fig. 183.) If time permits, the earth may be taken from a ditch in front.

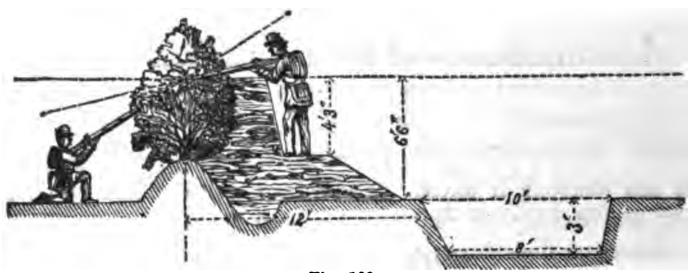

Fig. 183.

493. **Hedge under 6′ High.**—When the hedge is under 6′ in height, a small ditch should be dug in front, and the

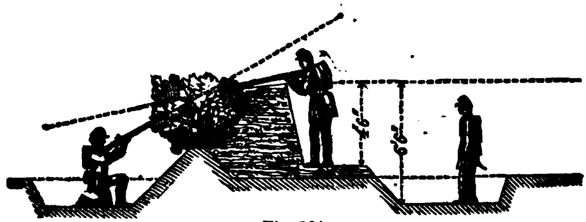

Fig. 184.

earth thrown over the hedge, a trench in rear being also made to provide the necessary cover. (Fig. 184.)

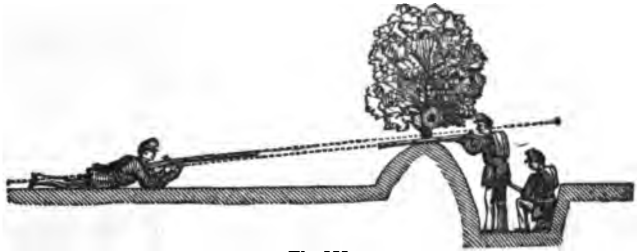

Fig. 185.

If there be a ditch in rear of the hedge, a very small amount of labor may provide cover. (Fig. 185.)

DEFENCE OF VILLAGES.

494. **Circumstances of Defence.**—A village may be held as an independent military post to be defended to the last, or as an advanced post, or part of a general line in front of an army. In the former case it should be entirely enclosed, while in the latter it would generally be left open in rear, and be strengthened only in front.

495. **Keep or Citadel.**—The first point to determine would be whether the whole, or what portion of the village, should be defended, and to select some substantial buildings as a keep or citadel. The buildings selected should have flank defence, support each other, and be proportioned to the numbers of the defenders; the greater and more exposed the open space around them the better; the keep should moreover be central and command all around it. Wooden houses and those with thatched roofs should be avoided, on account of the danger of fire, though if time admitted the roofs might be removed. Houses built of brick, if liable to be exposed to artillery fire,

are better than those of stone, as they do not splinter; they are also more easily loop-holed. Buildings with flat roofs are good.

496. **Construction of Defences.**—The entrances into the portions of the village selected for defence should be barricaded, or obstructed by means of felled trees, abatis, &c., though a few small and concealed places of egress should be left. The line should then be strengthened by turning hedges, walls, &c., into breast-works, and by making palisades, stockades, abatis, or any other obstacles. In selecting the line of defence, attention should be paid to flank defence.

497. **Ground in Front of Line of Defence.**—In advance of the line taken up, the houses should be demolished or burnt, the ditches parallel to it should be filled up, and everything levelled which would give cover to the enemy. Objects which would be obstacles to the enemy, and not afford him cover, should be left, such as *wet* ditches, palings, leafless hedges, &c.

Ditches, &c., perpendicular to the line should be left, as they would interfere with the enemy's flank movements and embarrass him. Trees which if felled would obstruct the attack, or if left standing impede the defence, should be cut down.

498. **Ground within the Line of Defence.**—Within the line of works, all fences, &c., that are perpendicular to the front, and interfere with a free communication to right or left, should be removed, while those that are parallel should be preserved, as affording protection to a retreat, and a further means of defence if the outer line be forced. It is important to have a second or even a third line of defence prepared, if possible, so that the troops if driven from one line by a superior force, may find others in the rear all ready for occupation and defence. Easy communications should be established between the several lines and the keep, and barricades should be arranged for closing them expeditiously. Detached buildings

may be connected by trenches covered over with planks and earth.

499. **Artillery.**—Artillery should be placed in the most commanding and inaccessible situations, and where its fire will defend thos) parts most favorable to the advance of the enemy.

DEFENCE OF BUILDINGS.

500. **Closing the Doors and Windows on Lower Floor.** —In preparing a building for defence, the first point would be to strongly barricade all the windows and doors on the basement and ground floor, and to cut ditches outside the doors and lower windows. One opening would probably have to be left for a communication; it should be on the side most protected, and most difficult for the enemy to approach, and should be made as secure as possible. The latter can be best managed by double doors, or other mode of making the interior, within the outer door, defensible.

Doors may be barricaded by boxes or casks filled with cinders or earth, placed against them to a height of 6′, loop-holes being made in the upper portions. Short lengths of timbers piled to the same height, with the ends secured in the side walls of a passage, or propped up with upright pieces on the inside, will effect the same object. Doors or window shutters may be rendered bullet proof by nailing on several additional thicknesses of planks, or fixing iron plates, and yet open as usual. If not made bullet proof, the defenders may fire *thro'* a door, when efforts are being made to force it. Fortified buildings have seldom been taken without forcing the entrance; too much pains, therefore, cannot be bestowed on making it secure.

501. **Windows.**—The upper windows need not be barricaded, but must be partially closed, and made bullet proof, if

possible, to a height of 6′ from the floor. This can be done by means of sand-bags, or short lengths of timber, or with carpets, blankets, or mattresses rolled up. A curtain hung across a window would be some protection, as it would screen from view the defenders, who might fire beneath it, kneeling on the floor. The glass should be knocked out of all the windows before the attack commences.

502. **Loop-holes.**—Loop-holes should be made in the walls on each floor, and, if possible, at every salient angle; they may be arranged in one or two tiers, as described for walls. Loop-holes can generally be made with great facility under the eaves of the roof.

It is desirable that day-light should not be seen through loop-holes, as then the enemy cannot tell when they are occupied. They are usually made 3′ apart.

503. **Flank Defence.**—If the building has no porches, wings, balconies, or projecting portions, from which flank defence can be obtained, tambours should be constructed; as many loop-holes, and as many tiers of them as possible, should be made in all flanks. Men can fire through loop-holes 22″ apart.

504. **Machicoulis Gallery.**—A Machicoulis gallery is used to enable a vertical fire to be directed on the enemy on the outside at the foot of the wall, and to facilitate pouring down melted lead and other missiles upon him.

A balcony may be converted into a Machicoulis gallery, by making the front and sides bullet proof, and forming openings in the floor through which to fire downwards; such a balcony forms an excellent flank defence.

If no balcony exists, a machicoulis gallery may be formed by breaking two or more holes through the wall on a level with the floor, and passing a stout beam through each hole. (Fig. 186.) These timbers may be lashed down to the joists, by passing ropes through holes made in the planks for the pur-

pose, or they may be secured to a transverse beam placed above them and against the wall inside the room; brackets may be fixed outside to support the beams.

The gallery is made 10 or 12 feet long and 2′ wide in the clear, and a bullet proof parapet 3½ or 4 feet high is made round it. Spaces are left between the flooring boards to enable the defenders to fire downwards, so as to defend the entrance. The most suitable weapons for this purpose are pistols; shells, hand-grenades, stones, &c., can be thrown on an enemy attempting to force the door.

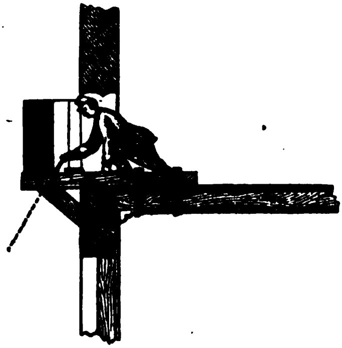

Fig. 186.—Machicoulis Gallery.

If a window serves as a communication to the gallery, it should be cut down to the level of the floor.

505. Expedients to Replace a Regular Gallery.—If a regular gallery cannot be formed, holes may be cut in the wall at a convenient height for a man to fire downwards, when leaning over, and a screen of wood or other material may be secured outside for protection. (Fig. 187.) If this be not possible, holes may be made in the roof through which grenades may be thrown over on the enemy.

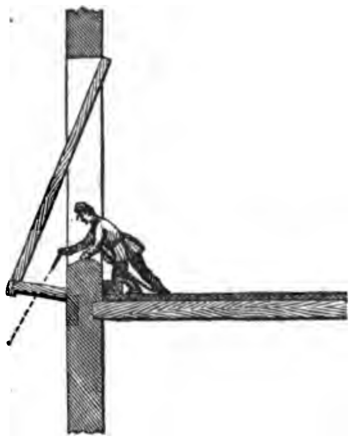

Fig. 187—.Machicoulis Gallery.

506. **Protection against Artillery.**—If artillery fire can be brought against the building, the walls may be partially protected by throwing up earthen masks round them. An exposed doorway may be protected from artillery fire by a blind-

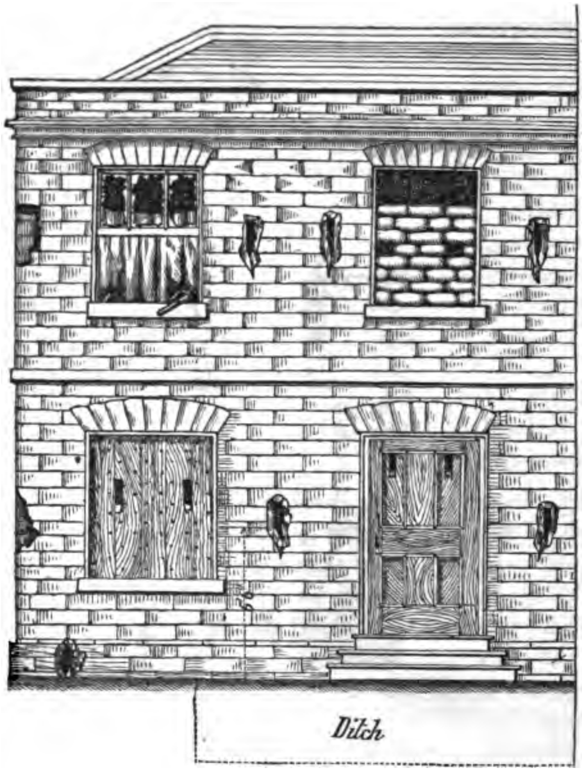

Fig. 188.—Defence of a House.

age or row of timbers touching each other, and with their upper ends leaning against the wall; outside the timbers a thick bank of earth or sand-bags should be raised.

507. **Interior Arrangements.**—The beams and joists should be shored up, so that if the enemy breaches the walls their partial fall need not necessarily be followed by that of the floors. Behind the barricaded doors, interior retrenchments of wood, furniture, &c., should be made. Means of barricading any breach in the lower part of the house should be provided.

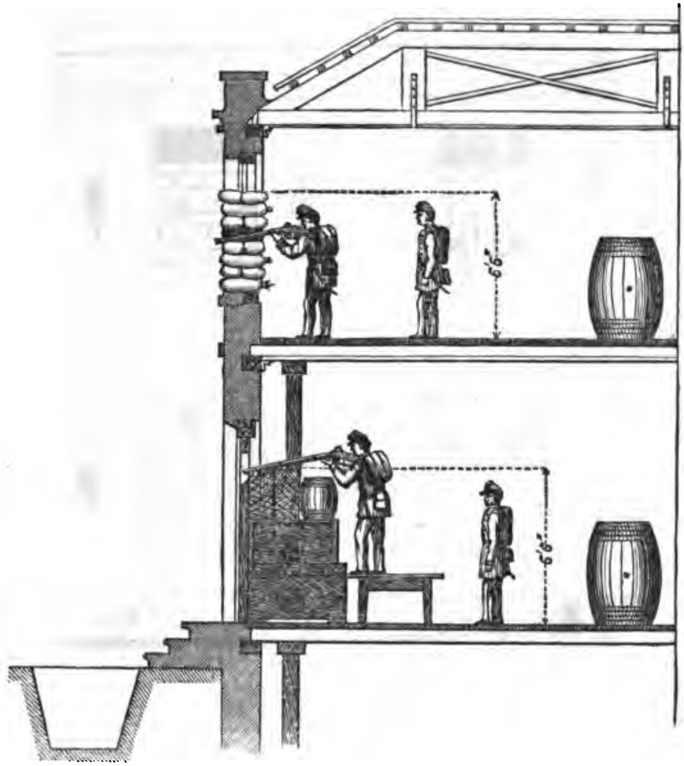

Fig. 189.—Defence of a House.

Communications should be made between the rooms. The staircases should be cut away, and ladders substituted, or arrangements should be made for barricading them. Openings

should be cut in the floor through which the defenders could fire down, so that if the lower part of the house were carried the upper might still be defended.

508. **Provisions, &c.**—Buildings for defence, not having a very free communication with reserve forces, should have an ample supply of provisions, which should be kept in the upper part of the house, where also a secure place for ammunition should be selected. In every room there should be plenty of water, not only for drinking, but also for extinguishing fire, against which every precaution should be taken. Figures 188 and 189 show a house prepared for defence.

PART IV.

MILITARY RECONNAISSANCE.

PART IV.—MILITARY RECONNAISSANCE.

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SECTION XVIII.—MILITARY RECONNAISSANCE IN GENERAL.

509. **General Definition.**—In the most general sense a military reconnaissance is that operation which has for its object to examine a tract of country both as to its topography and its military resources of every kind, the latter of course including the enemy's armed forces. From this definition it is evident that military reconnaissances vary between wide limits in character and magnitude. They may be made in time of peace or of war; in close proximity to the enemy or far from him; the force employed to protect them may be a whole corps d'armée, or a small detachment of cavalry, or they may be made without any armed escort; they may embrace all the territory controlled by one government, or only part of a position; they may require the highest order of military talent, or merely the mechanical skill demanded in making a rough survey.

510. **General Classification.**—Military writers have divided reconnaissances into two classes; viz., Armed, and Topographical. This classification is not entirely satisfactory, since many armed reconnaissances are more or less topographical, and the great majority of reconnoitring parties are armed. It has the sanction of the best authorities, however, and for convenience of description will be used here.

511. **Armed Reconnaissances.**—Armed reconnaissances are of several kinds, but the force of each is proportioned to

the strength and position of the enemy. Included among them are the daily explorations made by the advanced posts in front of camps and bivouacs, and by the guards around a fortress, to guard themselves from surprise, to prevent ambuscades, and to ascertain the position of the enemy if he is near. These are usually made early in the morning by patrols. Their operations are of short duration, say an hour, and extend only a short distance from the outposts.

If the enemy is distant, detachments are sent out on the front or flanks of his columns or camps. These detachments endeavor to bring in prisoners, from whom useful information may be obtained. When troops are on the march these reconnaissances are usually made by their advanced guard, or by detachments of flankers.

The most important armed reconnaissances are offensive reconnaissances. They are directed by the general in chief, or by a general officer designated by him. All the troops are under arms during the operation, and sometimes a majority of them take part in it. The object of this kind of reconnoissance is, by a show of attacking the enemy, to compel him to draw in his outposts and draw up all his troops for battle, in order to ascertain his exact position and numbers. These reconnaissances are often the prelude to real attacks, sometimes to battles. They belong to grand tactics. They are not so useful in modern times as they were formerly, when it was the custom to draw up all the troops in order of battle before the fight. Of course the study of the ground is an important element of these reconnaissances.

512. **Topographical Reconnaissances.**—Topographical reconnaissances vary ad infinitum. They may relate to an entire country, or to a province, a locality, &c. Those which embrace everything a country or province contains of a military character, that is to say the descriptive, statistical, military, and historical parts, are general reconnaissances. Those concerning

localities, or particular objects, for example, a road, a stream, a position, &c., are special reconnaissances.

General reconnaissances are usually executed in time of peace or, if during war, in rear of the lines of an army. A government should be acquainted with the strength of its neighbors, and with everything which contributes to that strength; the military organization; the instruction, discipline, and spirit of the troops, both regular and temporary; the readiness of the people to support war; the possibility of raising up factions; the numbers to which the army could be raised; the general features of the country, the mountains, rivers, fortresses, communications; the climate, the abundance of food and animals; the relative advantages of different lines of operation; the proportion of troops of the different arms which the nature of the ground requires; what places may become depots; the means of transportation; &c. Still more should it be acquainted with its own territory, in order to be prepared for an able and energetic defence. It is rare however that, on the breaking out of war, it is not necessary to have the frontiers reconnoitred by able officers, and new researches made concerning the enemy's country.

In time of war, when the armies are in the field, examinations of the ground are less extended than those which have just been referred to; they are effected by expeditious means; sketches are made instead of maps, and the written reports contain only particular but detailed explanations, referring especially to the object designated by the instructions. The object of the war is known, the lines of operation are determined upon, the army has been composed according to the nature of the country. General notions have been sufficient for this, but actual military operations demand much more detailed information, while at the same time it is obtained under greater difficulties. Hence a great number of special reconnaissances are necessary. The object of these may be a river, a chain of

mountains, a road, a forest, a town, a military position, a fortress, a bridge, a defile, &c., &c., or a district. They are made by officers of the staff or line, escorted, if near the enemy, by small detachments of troops. A sketch of the ground must always be made, if practicable.

513. **Conclusions.**—The foregoing remarks show the magnitude of the subject of military reconnaissances. It is evident that a complete treatise upon it would of itself fill a volume. No more can be done here than to give the general principles of field sketching, illustrated by examples, and a detailed account of the two kinds of special reconnaissance selected for the practical instruction of Cadets at the Military Academy. The second of these, the reconnaissance of a route for the march of a column of troops, partakes somewhat of the nature of a general reconnaissance, though the information is to be much more minute; and it may be here remarked that it is no more possible to classify reconnaissances and give each class its name, than it is to classify the degrees of knowledge itself.

SECTION XIX.—FIELD SKETCHING.

DESCRIPTION—APPREHENSION OF GROUND—ESTIMATING DISTANCES —INSTRUMENTS, &c.—OPERATIONS OF FIELD SKETCHING.

DESCRIPTION.

514. **Field Sketching compared with regular Surveying.**—It is assumed that the student is acquainted with the principles of regular surveying. The same principles are employed in irregular surveying or field sketching. The difference in their application is that, in the latter, the chain is replaced by pacing, or the rate of a horse, or the judgment of the eye for measuring distances, and the angles are measured by the eye, or by portable instruments, such as the compass or box sextant.

515. **True way to Learn to Sketch.**—There is no method in existence for teaching at once how to sketch ground, without using instruments and without taking measurements. Men who have the power of putting down on paper the form of ground that they pass over in their walks or rides, have acquired it by the use of instruments. By taking angles and measuring distances, their eye has been trained to estimating them. Whoever wishes then to learn to sketch well without instruments, must first use instruments constantly and study topography carefully.

516. **Classification of kinds of Field Sketching.**—Field Sketching may be divided into two classes; 1st, sketching

at leisure, and under no restrictions from the neighborhood of the enemy; 2d, sketching against time, and in the neighborhood of the enemy.

517. **Difference between the Two Classes.**—In both cases the degree of detail must depend on the object in view and, in the latter case, on the time and opportunity afforded by the enemy. In the first, every feature of any importance may be represented. In the second, nothing should be noticed that can be omitted. For example, in the first, in the case of a chalk district, in which the streams are usually few and small, it might be proper to notice a rivulet, but it would be absurd to notice it in the second when insufficient to stop infantry—unless the ground were to be that of a camp, when the stream might be of consequence as a water supply. What is wanted in the second is something simple and effective, that can be executed quickly and be easily understood.

518. **Previous Study necessary.**—Facility in field sketching is only to be obtained by being familiarized with ground, as the result of previous study and practice.

APPREHENSION OF GROUND.

519. **Appearance of Ground to the Inexperienced Eye.**—It is a very common error with beginners to regard hills as isolated features, as they often appear to the eye. The elevations and depressions of ground, the plains, rivers, and torrent beds, present to them nothing but irregularity and confusion. As the eye becomes more experienced, however, these forms will be recognized as the results of general laws of nature.

520. **Master Lines of Ground.**—As a general rule the present forms of ground are due to modifications caused by the action of water, seconded by the atmosphere. There are

certain lines which must be examined first, and to which all other objects will be referred. These lines are the water-courses, and the summit lines of the ridges or water-shed lines, as they are called from their separating the waters. They are the salient characteristics of the earth's surface, the bench-marks for every reconnaissance, and those which it is necessary to examine with greatest care. A clear and complete idea of their importance, and of the close relation between them, is the foundation of a knowledge of topography.

521. **Primary Water-shed Line.**—If we examine a good topographical map of any island, it will be seen that a person can pass over it from one end to the other, upon a more or less sinuous line, without crossing any river or torrent. This line contains the most elevated points of the island, and divides it into two slopes which shed water in opposite directions. It is the water-shed line of the island.

Every continent presents the same feature. It is composed of two slopes, starting from the sea and rising towards the interior. The line of intersection of these slopes is the water-shed line. It is not everywhere a straight line, or nearly so, neither is it uniform in height; in flat countries, it is even difficult to detect it.

522. **Secondary Water-shed Lines and Secondary Slopes.**—Upon a careful examination of the map, we perceive that there exist other water-shed lines, leading from the first, or primary, water-shed to the sea, which likewise cross neither rivers nor torrents, and present inflections in their directions and inequalities in their heights. Each of these water-shed lines of the second order necessarily gives rise to slopes which shed the water, and these slopes will intersect each other at bottom in lines perpendicular or oblique to the sea shore. It is evident that these lines of intersection of the secondary slopes will be a series of the lowest points lying between the secondary

water-sheds; and therefore that all the water of that portion of ground between any two will flow along this line of intersection.

523. **Primary Basin.**—That portion of a continent lying between the primary crest and the sea, and enclosed between two secondary crests, is called a primary basin. The stream through which its waters flow is called a river of the first order, as the Mississippi.

These primary and secondary water-shed lines are then the great geographical lines of the continent. The division of the continent into basins independent of each other simplifies the labors of an officer in explorations.

524. **Water-shed Lines of the Third Order, and Basins of the Second Order.**—The advantage will be greater still if he decomposes each of these basins in turn. Following carefully the secondary water-shed lines, we see that a person can go from them to the river, without crossing any stream or torrent. Such a journey is made along water-shed lines of the third order. The ground included between two crests of the third order is called a basin of the second order, and the stream which empties its waters a river of the second order, as the Ohio.

525. **Basins of the 3d, 4th, and 5th Orders.**—In this manner we find that basins of the second order are subdivided into basins of the third order, which are emptied by small rivers or creeks; these again into basins of the fourth, and then into those of the fifth order, which in their turn are emptied by rivulets or torrent beds.

526. **Conformity between the Two Master Lines.**—There is then a close conformity between these two lines. The ridge lines are ramified exactly like the watercourses which they enclose. In aqueous formations, they are always nearly

parallel to each other. (Fig. 190.) In igneous formations, this parallelism is not so apparent when we consider the higher crests, but as we descend it increases. In formations of loose

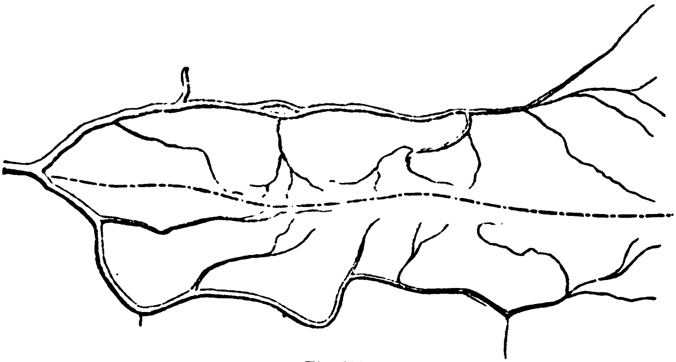

Fig. 190.

sand and gravel, as the hills vary with every wind, there is no regular connection between them, and they are represented conventionally.

527. **Master Lines assisted by Horizontal Contours.** —These two directing lines, if traced with care, will alone give some idea of the nature of the country. They are of the greatest assistance in sketching the hills, as *the contour lines always cut the ridge lines and all lines of greatest inclination at right angles.* The representation of the ground is completed by means of horizontal contour lines. These are the lines which would be traced out on the ground by successive risings of a flood to different levels. In other words, they are the intersections of the surface of the ground by horizontal planes. These horizontal planes are usually taken equally distant from each other, and their height above some fixed plane of reference being known, the plan of the contours, with these heights marked upon them, gives a perfect representation of the ground, in relief as well as plan.

528. **Ground to be Examined from a Distance.**—Practice in regular surveying will here be of the greatest benefit to the student, as it gives him a knowledge of the true forms of ground. The beginner will almost invariably estimate the slopes as too steep, and is much surprised, on making his first section, to discover the low relief of ground which he considered quite high and abrupt. When on a hill, the eye takes in so little at a time, that he is apt to give too great a roundness to his curves. It is desirable therefore to examine the ground from a distance for general correction as to relative importance of different features, after the local details have been collected on the spot. The best time for this is a little after sunrise, or a little before sunset.

529. **Application of Contours and Hachures.**—Horizontal contours are now generally used in preference to the vertical method, or hachures, though some persons prefer the latter for representing very steep ground. Both styles are objectionable when they are made, unnecessarily, to supersede the simple outline for the main features. The best plan is to combine both, when notes are being taken for a finished map, to be completed afterwards; but when the sketch is to be finished at once and as quickly as possible, as in reconnoitring a position in presence of the enemy, the rough hieroglyphics of Plate III. are far preferable.

530. **Valleys.**—Valleys are not composed of two simple slopes, but generally of several successive planes, sloping down

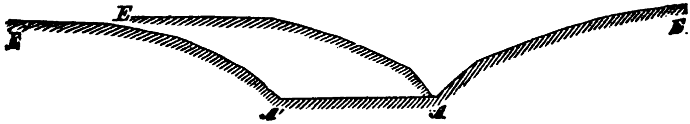

Fig. 191.

from the water-sheds E E′, (Fig. 191) and meeting at A, or separated by a flat valley bottom A A′.

If two such valleys intersect one another, a groin-shaped space will be formed; and it is important in sketching that the general form of the main valley be traced out, as if it had never been invaded by the cross one. Thus in sketching the valley of a river, the whole valley should be traced out with the idea that the strips cut out by ravines, &c., are still in existence. The same rule applies to sketching the ravines themselves, with reference to their own branches.

531. **Sinnosities of Rivers.**—When a river runs along a broad valley flat, as on A A′ (Fig. 191), it is constantly changing direction, as if repulsed and rebounding from one side to the other. At the elbows thus formed, the banks will be steepest on the concave side, even to sometimes being vertical cliffs. At all sudden turns of the valley, the river will be found on the concave side of it.

ESTIMATING DISTANCES.

532. **Estimating Distances.**—Skill in estimating distances is indispensable in sketching ground. Every officer should know the length of his regular pace, and the average speed of his walk, as also that of his horse. The habit of guessing distances, which can afterwards be verified, will tend to correct the eye. He will be assisted in this matter by carrying a pedometer in his pocket, and frequently noting the distances he has passed over in his walks for pleasure or exercise.

533. **Estimating by Appearance of Objects.**—Ordinary eyes, in ordinary weather, can count the windows of a large house at the distance of $2\frac{1}{2}$ miles, perceive men and horses as points at $1\frac{1}{2}$ miles, clearly distinguish a horse at $\frac{3}{4}$ mile, clearly distinguish the movements of men at $\frac{1}{2}$ mile, distinguish the heads of men occasionally at 750 yards, and distinguish them well at 450 yards.

An observer accustomed to estimate distances in a flat country will be apt to underestimate in a mountainous one. When facing the sun, objects appear much nearer than when the back is to it.

534. **Estimating by Velocity of Sound.**—The velocity of sound may be of assistance. It travels about 1,100 feet per second. A light breeze will increase or diminish this quantity fifteen or twenty feet in a second, according as its direction is to or from the observer; in a gale a considerable difference, 70 or 80 feet, will arise from the effects of the wind. A common watch generally beats five times in one second. The pulse of a healthy man generally beats about 75 times per minute. Either of these may serve as a substitute for a seconds watch. The time in seconds between the flash of a gun and the hearing of the explosion, multiplied by the velocity, will give the distance of the gun.

INSTRUMENTS, MATERIALS, &c.

535. **Instruments.**—The only instruments generally necessary in Field Sketching are the common box compass (Fig. 192), graduated from 0° to 360°, the numbers increasing in the direction of the hands of a watch, and the north and south line being parallel to the side to which the cover is hinged; and a rectangular protractor (Abbott's is the best) arranged with a scale. Abbott's protractor differs from an ordinary rectangular one only in the graduation—which runs from 0° to 180° on the one side, and from 180° to 360° on the other, both marked from left to right—and in having a scale of tenths of inches marked on both sides and connected by lines running over the edge.

In districts where iron in a magnetic form abounds, instruments for taking included angles, instead of bearings, must

be substituted, such as the pocket sextant. A description of the latter and its use may be found in almost any book on military surveying.

The hand level also is often used for sketching contours.

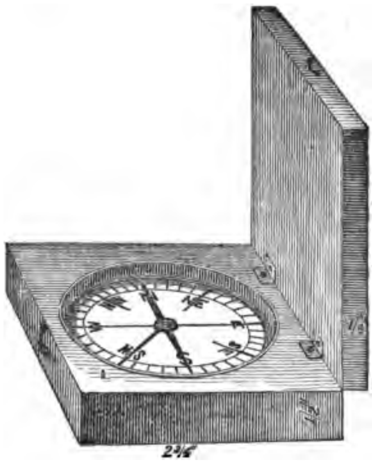

Fig. 192.—Box Compass.

536. **Sketching Paper.**—The most convenient material to sketch upon is paper ruled in squares of one fifth of an inch on a side, the lines being very light, with those of the inch divisions slightly more prominent. With such paper a separate scale may be dispensed with.

When this cannot be procured, common foolscap paper, ruled with the light blue lines as it is sold for writing paper, will be found convenient, the blue lines being used as so many magnetic meridians.

537. **Drawing Board.**—The paper should be stretched on a light drawing board, 16″ $\times$ 20″ and $\frac{3}{4}$ inch thick, made of pine. To prepare the paper for work, take as many sheets as may be needed to cover the ground to be sketched. Lay them

one over the other on the board, and at each corner push in a tack with the thumb, turning the corners of the paper under to give it a better hold on the tacks. When in the course of the work the object does not fall on the first sheet, the tacks are pulled out, the second sheet placed over the first, and all are fastened down again.

538. **Other Sketching Materials.**— Other articles needed will be a small memorandum book, lead pencils, green, blue, and red crayons, knife, india-rubber, and a few tacks.

539. **Use of Compass.**—Hold the compass horizontal in the left hand, the lid being raised to a vertical position. With the forefinger of the right hand check the oscillation of the needle by means of the stop. Sight along the vertical lid of the compass box, and having brought the object into the plane of the lid and allowed the needle to come to a state of rest, clamp the latter and take the reading. Care must be taken always to read the same end of the needle.

540. **To Plot a Bearing.**—To plot any bearing, as 48° from *s* for example, (Fig. 193) lay the protractor on the paper in such a manner that the centre *c* shall fall on one of the meridian lines, and the division 48° on the same. Slide the protractor up or down, until the edge *a b* shall pass through *s*, taking care that the above-mentioned points continue on the meridian line. Then draw a line along the edge *a b*; it will represent the bearing taken.

541. **Scale for Sketches made on Foot.**—The measured distances are plotted on a scale of 1″ to 400 paces, or about 5″ to the mile, when the sketch is made on foot. While the sketch is being made, it will not usually be necessary to know the exact length of the paces; but after its completion, a scale of yards should be appended to it. This scale is constructed as follows. First find the length of the pace. To this end pace

over some known distance and count the number of paces. Divide this distance expressed in feet by the number of paces; the result will be the length of each pace in feet, which call p.

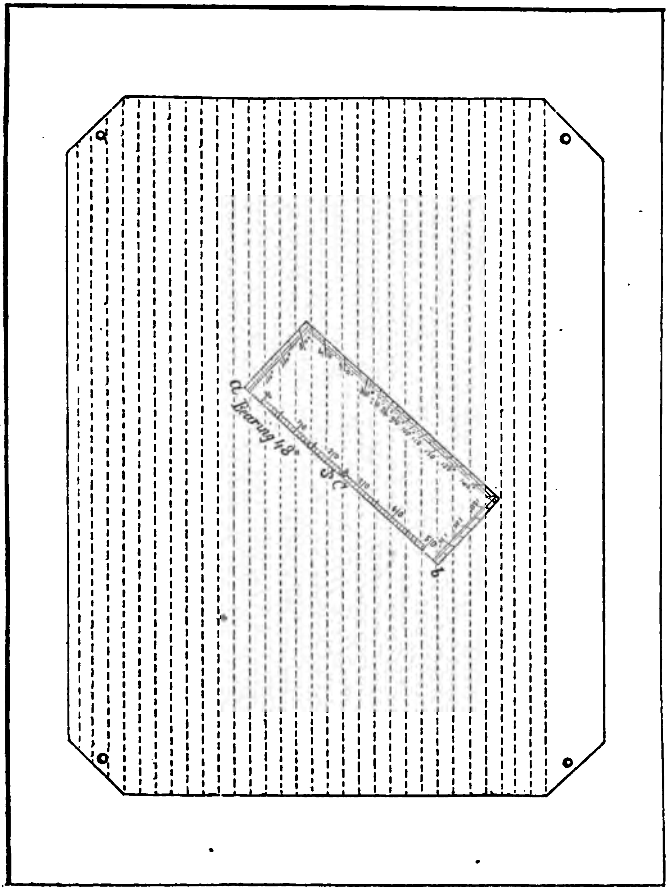

Fig. 193.—Drawing Board.

Since 1″ on the sketch represents $400 \times p$, the length which will represent 400 yards, will be found by the proportion

$$400 \times p : 1'' :: 400 \times 3 : x.$$

For example, suppose the distance paced over to be 1000′, and the number of paces to be 397. Then the length of each pace will be $1000 \div 397 = 2.52'$ and $400 \times 2.52 = 1008.0$.

$$1008 : 1'' :: 1200 : 1.19''.$$

That is, if an indefinite right line be divided into lengths of 1.19″, each length will represent 400 yards. It will then be subdivided and numbered as shown on Plate II. This scale will of course be different for each individual.

542. **Scale for Sketch on Horse-back.**—For rapid sketching done from the saddle, a scale of two inches to the mile will generally be large enough. The distances being measured by the time it takes the horse to pass over them, it is necessary to know the rate of the horse. This is obtained by letting him move over some known distance at his regular gate, and noting the time required, and thence deducing the time it would take him to move over a mile. If the map be plotted on a scale of one inch to ten minutes, when the gait is a walk, it will be on about the scale indicated above.

For special purposes, it may be desirable to have a larger scale. One inch to four minutes corresponds to about 5″ to one mile. This will be as large as the accuracy of the notes will justify.

The scale of miles, constructed in a manner analogous to that described in the preceding paragraph, will be appended to the sketch.

543. **Use of Hand-level.**—The hand-level is used in sketching at leisure, for putting in the contours. This is done after the plan of the ground has been made, showing all the roads, streams, houses, fences, &c. The vertical distance apart of the contours is usually taken at 10′. A spot is selected, near the lowest point of the survey, for the reference zero, and a course is run up the steepest hill-side bordering it. Standing at the bottom, and holding the hand-level horizontal at the

height of the eye, note where the line of sight intersects the trail on the hill side. The height of the eye being about 5′ from the ground, place the feet at the point found, and the eye will then be in the plane of the 10′ contour. Sweep the level over all the ground within view, and note on the sketch the points where it intersects the surface, as referred to objects already fixed upon the paper. Trace the curve through these points, and mark it (10). Repeat the operation for the 20′ curve, and so on until the hill-top is reached; and then continue the work by running other similar courses until the contours are traced over the entire sketch.

OPERATIONS IN FIELD SKETCHING.

544. Field sketching, like regular surveying, comprises four operations; 1st, preparation of the skeleton diagram or outline; 2d, putting in the details in plan; 3d, levelling, by means of which are represented the formations of the ground, the character of the slopes, elevations, depressions, &c.; and 4th, plotting the work on paper. In sketching at leisure a limited extent of ground, the fourth operation is combined with the second, and also with the third.

545. **First Operation.**—The first operation consists in fixing upon the sheets to be used in the sketch, the position of the principal points of the ground. Maps can nearly always be found, showing the watercourses and communications with sufficient accuracy, and these furnish the necessary data. Even if the map show only the position of villages, principal communications, and important streams, the skeleton diagram can easily be finished from it by connecting the most striking intermediate points with those given. Of course the scale of the map must be altered to that which is to be used.

If no map can be found, or that found is too inaccurate to

answer, a series of rough triangles may be made, taking church-spires, tops of hills, crags, single trees, &c., as stations.

Should the country be level and wooded, so that remarkable objects cannot be seen from each other, the only resource is to go over it. A polygon is sketched whose sides follow, as far as practicable, the roads and watercourses which circumscribe, or nearly so, the ground. Should there be commanding points, they will be fixed on the paper by intersections, and thus serve to verify the work as it proceeds.

Generally, the polygon will not close. Taking the most unfavorable case, that in which the officer has no instruments, and is not trained in estimating angles and distances, he will proceed as in regular surveying, to pass over its perimeter, and will estimate the sides and angles as well as he can. The angles will be estimated either too large or too small. Adding them together, their sum should be equal to twice as many right angles less four as the polygon has sides, supposing that there are no re-entrant angles; if it is not, the total error of all the angles will be known. Dividing up this error among them equally, they will be partially rectified, and the polygon will close as far as the angles are concerned.

If the polygon still does not close, it is evidently because the distances have been estimated too great or too small, and the length by which their sum appears to be in error must be divided up among all the sides.

To complete the skeleton diagram, after having closed the polygon, which is taken as a base, it is only necessary to sketch the interior communications. This can be readily done, since the general direction of the majority of them is already fixed.

546. **Second Operation.**—In filling in details, the work is commenced at any angle of the polygon, and each of the partial polygons which constitute the skeleton diagram is filled in in succession. The location of the different objects may be

made by estimating their abscissas and ordinates referred to some line already fixed.

547. **Third Operation.**—In a military sketch, the representation of the elevations and depressions of ground is as important as the plan. In sketching on foot and at leisure, this is done as described in par 543.

In sketching contours, it must be remembered that every contour is an endless line; that is, if continued long enough, it will come back to the place of beginning, and thus *enclose* a certain extent of ground. It may happen that two contours on the same level approach each other very closely, and may even be tangent to each other for a certain distance, though such tangency at *more than one point* is a very rare accident; but it is impossible for two contours on the same level to meet and be merged in one. Such an absurdity is often committed by beginners, when the contours approach close to each other.

548. **Fourth Operation.**—In sketching for military purposes, there is not usually time to transfer the work to a new sheet before it is needed. For immediate use, the original drawing may be effectively finished by coloring the roads with a red, water with a blue, and woods with a green crayon, and appending a scale of yards to it. The usual topographical signs, of which the most common are shown on Plate I., are employed in making the sketch, with more or less care, according to the time at disposal. Afterwards, if desirable, the sketch may be transferred to another sheet and compiled with other similar sketches.

549. **Copying Maps.**—The rapid copying of maps compiled from Field Sketches may be considered an extension of the fourth operation. This is done by tracing the map upon linen and then printing upon sensitized paper as in photography, either directly from the tracing itself, making a black tinted map with white lines, or from a paper negative derived from

the tracing, making an ordinary map with white ground. The former is more rapidly multiplied, but the latter is more convenient if pencil additions are necessary.

550. **Remarks on the Apprehension of Ground.**—It will be observed that the foregoing operations can be executed for *positions of limited extent* by persons who need have no great familiarity with the principles (except those concerning horizontal contours and valleys) laid down under the head of Apprehension of Ground. This is not true, however, of the directing head who is to compile the work of a number of assistants; nor of one who, in reconnoitring a position in the presence of the enemy, must work with the greatest rapidity, guessing at what he cannot see. In these cases such knowledge is absolutely essential; but still more so, if possible, is it to one who has to represent a considerable extent of country.

551. **Sketching from the Saddle.**—In sketching from the saddle, the general principles are the same as before. The distances are measured by the time it takes the horse to pass over them. The latter is to be kept at a regular gait, particularly is not to be urged in going up or down hill or over rough places, for it is the distance in *hours of march* that is wanted rather than the absolute distance.

In sketching the slopes, as there is no hand-level to aid, the officer must observe whether the ground falls across a road or wood, or only to it, and whether the fall be perpendicular, oblique, or parallel to the direction of the road. He must then estimate the distances to the extremities of the slopes, correcting his judgment by measurements as often as he can. He should be particular to notice whether the slopes are practicable for infantry, cavalry, or artillery, and at what gait cavalry can ascend without unfitting the horses for immediate action.

A slope of about

60° or 7 on 4 is inaccessible for infantry.
45° or 1 on 1 is difficult " "
30° or 4 on 7 is inaccessible for cavalry.
15° or 1 on 4 " " " artillery.
5° or 1 on 12 is easy for wheel carriages.

552. **Sketching a considerable extent of Country.**— In sketching a considerable extent of country, there are two errors which are very common with a beginner; 1st, beginning the work without first tracing out some methodical course which he intends to follow; and 2d, trying to finish at once the representation of everything within view, the latter error being a natural consequence of the first.

The proper way is to begin by examining, upon the maps of the country, the principal watercourses, and from them the direction of the principal heights and valleys; then to form a rough diagram upon which will be traced out the course most proper for sketching the country with order and celerity. Then while sketching a valley, it must not be attempted to represent a height which is half a mile off; and trying to sketch all the branches of a valley from a single stand-point must be avoided. Such a manner of working would only cause error and confusion.

The sketcher should, if possible, keep on the heights, or at least high up on the slopes of the valleys. If he cannot go there with his horse, he should dismount, and have his horse led at the bottom until he can rejoin him. If he remains in the valley bottom, he can generally see only in front and behind him. He must be very careful about leaving his horse, however, when near the enemy; it is his duty to avoid all serious risk of being captured.

1st Example.—Sketching at Leisure.

553. Plate II. represents a portion of a map, made by the method of sketching at leisure, at the school of practice at Willets' Point.

The roads A B, B C, G H, F I, C D, and A E, were shown on the county map of Queen's County, the road A E intersecting C D a little to the right of the limit of this sheet.

A short preliminary examination of the ground showed that it consisted of a well-defined ridge running nearly east and west, densely wooded on and near the summit, and terminated on the north by gentle undulations and on the south by a nearly dead level; also that a road from L ran towards the ridge, though it was not known where that road terminated.

The above network of roads formed the skeleton diagram, and was first employed in dividing up the work among the assistants. Beginning at A, one sketcher was sent over the road from A to E, with orders to sketch the road itself, and all objects west of it, until he should meet the sketcher coming from the opposite direction; one was sent from A to B, to sketch that road, and all objects south of it, as far as the dense woods; one from L, to follow up that road to its terminus, sketching to the right and left as far as the woods should permit; one over the road F I, to sketch to the southward as far as the dense woods, and northward to the road G H; and one from F to C, to sketch to a distance of half a mile west of the road, and then to work eastward to meet the first sketcher on the south side of the ridge. It is evident from the finished map that this arrangement gave to the first and last assistants an unduly large share of the labor in putting in details, as well as in the actual distance passed over. This was not so apparent from the county map, though that showed that the distance would be greater. For the latter reason, commissioned officers were assigned to these portions, the other assistants being non-commissioned officers.

Each sketcher assumed his road as a base, taking its bearings and pacing its distances with care, and referring all objects to it. As an illustration, it will be sufficient to follow for a short distance the first one.

Beginning at A, he took the bearing A a, and having marked the direction of that line on his paper, paced the distance to a, which he found to be 456 paces; laying off this distance on the scale of 1″ to 400 paces, the point a was fixed. From this point he observed and plotted the bearing of the road $a\ b$, and that of the corner of the fence a^1, and then paced to b, which distance he found to be 100 paces. Laying off this distance with his scale, b was fixed, and he then took the bearings of the road $b\ c$, and of the house b^1. From c he took the bearing $c\ d$ of the road and $c\ b^1$ of the house, the intersection of the latter with $b\ b^1$ fixing the position of the house, and then paced towards d, as far as c^1, a distance of 25 paces. Having fixed c^1 on his paper, he took the bearing of the fence $c^1\ a^1$, this bearing with the one taken from a serving to fix the limits of that fence. He then continued to pace towards d, as far as c^2, a distance of 270 paces, when he stopped to take the bearing of the fence $c^2\ c^3$, after which he finished pacing the distance to d. From d he took the bearing $d\ e$, and then paced to e, fixing that point on his paper. At e he took the bearing $e\ e^1$ of the fence, and then left the road to pace the distance to e^1; then from e^1 to e^2 and so on until he had put in all the fences in that vicinity. Then returning to the road, which here entered the woods, he followed it up carefully until other objects took him off of it again temporarily. In this manner every fence, house, or other object to which the contours could be referred, was carefully located upon the sketch.

After the completion of the sketches in plan, the contours were put in. In order to insure consistency in the contours over the whole ground—of which this sheet represents but a small part—the heights of the points A, L, B, and C, above the water were accurately ascertained by the Y level.

The height of L was 65 feet or, in technical language, its reference was 65. The sketcher standing at L, his eye was in the plane of the 70′ contour, and sighting through the hand level, he noted on his sketch the points n, n^1, n^2, n^3, where his line of sight intersected the fences, &c.; tracing a curve through these points, he marked it (70). Then proceeding to n^1, he sighted upon the road the point o; placing his heels at o, his eye was in the plane of the 80′ contour, and with his level he sighted the points o^1, o^2, o^3, and o^4 as before. Proceeding then to o^1, he found that along the road the ground rose for a short distance and then fell away. His line of sight, which was 5′ above o^1, did not intersect the road itself, but did intersect the fence at the side. Noting some distinguishing mark in the fence, which lay in his horizontal line of sight, he advanced beyond the summit of the elevation, and then sighted back on the mark in the fence. Changing his position until his eye was in the same horizontal plane with this mark, his feet were then at the reference 80, at the point r. Advancing still farther and sighting back upon r, he placed himself at r^1, and then sweeping his level, he traced the 80′ contour; and so on.

A large portion of the ground being covered with thick woods, in which there were no marked objects to which to refer the contours, the method adopted was to run courses straight up the sides of the ridge, keeping as nearly as possible on the prolongation of some fixed line, as $x\,x$, $y\,y$, and estimating the horizontal distances between the contours.

2D EXAMPLE.—SKETCHING IN THE PRESENCE OF THE ENEMY.

554. The following is a specimen of work done by Maj. Gen. Bainbridge of the British Army, as described by himself. Plate III.

"Dublin, *5th January*, 1846.

"Having been requested by the Editors of the *Aide-Memoire* to give a specimen of the sort of sketch of a position required during the Peninsular War, with an account of the mode of performing the work, the annexed, which I was required to make by his Grace the Duke of Wellington in Spain, is supplied accordingly; and the following is a statement of the circumstances under which that sketch was ordered, and the way I took to perform it.

"In 1812, when the French army, under Marshal Marmont, was crossing the Tormes, at Huerta, above Salamanca, before the forts of that place were taken, the Duke—at that time standing on the high ground in front of Cabrerizos, observing the enemy—desired me to cross the river, and see what sort of a position there was in a certain assigned direction, for stopping the advance of the French, and to make a sketch of it as quickly as possible.

"There were about two miles to ride to the ford of Sta. Martha, and perceiving at once that that point would be the left of the position, on having crossed, I began at the point A.

A. "The lines of direction to B, C, D, E, F, G, were first laid down, sketching in the river, the roads, the village, and particularly the church of Sta. Martha. These lines of direction were, in fact, so many angles laid down and protracted on the sketch, but no instrument was used, as there was no time; everything was done by the eye. I did not dismount, and galloped from station to station.

C. "Having finished at A, I went along the road to Huerta (C), a farm of only two or three buildings, which was the only point to be seen in that direction from A; judging then this distance galloped over, the line from the church of Sta. Martha to C was assumed as a base.

"It was desirable that this front of the sketch towards Huerta should be done first, as the enemy's skirmishers were

exchanging shots with ours between C and Pelobravo (M), when I reached that ground.

"C being fixed, the lines to H, I, J, K, L, M, were laid off; the line H intersecting the line B, showed where the rivulet joined the Tormes. The line J, intersecting A E, showed nearly where the steep fall of ground at J would come. The line L pointed out where the road to Calvarosa Abaxo crossed the rivulet, and to that point (N) I went.

N. "Here the angle between Sta. Martha and C was laid off, which fixed N, and then intersecting the lines I and K (taken from C), those two farms were fixed. The direction (O) of the stream was noted, and also the line to J was intersected; also a fresh object (P), a remarkable tree, was taken, as it was the only object between J and P, along the crest of what would obviously be the position.

Q. "The village (M) could not be seen; I therefore went to the rising ground (Q) from whence it was visible; at this point it was observable that I was in a line with the farm (K) and Sta. Martha church; then, assuming that line to be correct, the angle between Sta. Martha and C was laid down, which thus fixed Q. The next angle was that between C and M, by which the village M was fixed.

P. "Proceeding from Q, up the hill, to P, the angle was taken formed by N and Sta. Martha, which fixed P; it was also noticed that the line to the farm (I) passed to the right of the farm (K), which observation helped to correct the sketch; also it could be seen that the line to H passed over K. The direction (J) was next taken, showing the fall of ground and the direction of the road (D). There were no other points that could be fixed between D and the skirt of the wood (R).

R. "I then galloped to the top of the hill, and placing myself in a line with the two farms (I and K), that line was assumed to be correct; and then observing the angles between K and Sta. Martha, between K and C, and K and P, R was fixed.

"At R, I could see (over the trees) the village of Calvarosa Ariba, and also a chapel (called an Hermita) on this side of it, the directions to which were taken; also to the remarkable hill (S), and the abrupt slopes of the ground to the rear (U and V).

"A line was drawn to the fall, or gap in the ground (T), taking great care that this, as well as those to S, Calvarosa, and the chapel, were as correct as possible in regard to the line from P, because the connection of the right of the position rested on this point, and the accuracy of the winding up of the sketch would depend on the correctness with which those angles were taken.

T. "Next to T; and as, on reaching it, it was clear that none of the points on the left of the position could be seen except R, it became necessary that the distance from R to T should be judged as accurately as possible—which distance became a fresh base. At T, thus fixed, all the right could be seen, and the Hermita could be intersected, as well as the ground to the rear (U, V, and E). The direction (X) of the smaller hill was taken, and the line over its summit, it was observed, passed to the abrupt right-hand slope of the ground (W), to the rear of the position. A farm also, in a hollow of some wood to the front, was noted.

X. "I then went to the smaller hill, intending to go to the top, but the rocks were so rugged I could not ride up; so, standing on a line between it and T, at X, that station was fixed by observing the direction to E and to the Hermita.

"The line to Calvarosa from R was next intersected, which fixed that place. The direction to the houses (Z) was also laid down, and this place turned out to be the village of Arapiles; and the two remarkable hills were the celebrated hills of the same name.

"The line W being intersected, gave the boundary of the ground (Y); the farm in front, observed from T, could no longer be seen.

"Passing, then, down by the right and along the hollow between the two great hills, I went to the Hermita, and this point having been before fixed, from thence the direction of the further fall of the great hills (S) and two slopes of the hill on the further side of the Calvarosa valley were secured, as well as the direction of the watercourse above and below. I then passed down the valley, and wound up the sketch at O.

"Going back from thence to C, I proceeded along the main road to D and E, putting in, on judgment, the village of Carvajosa, as well as the point F, where was a house, and where the great Salamanca road passed.

"I returned to Cabrerizos, finding the Duke where I had left him, and handed him the sketch, having been absent about two hours and a half. I made a verbal report to his Grace, pointing out the high hill (S), which we could plainly see from the spot where we then stood, observing that it was doubtful whether guns could be brought there, not having had time to ride thither. The Duke gave me back the sketch, to put it in ink, which I did, sitting down on the ground, and I returned it to his Grace.

"In the afternoon of that day the position just sketched was occupied by part of our army; and the enemy having by signal communicated with the forts of Salamanca, re-crossed the Tormes at Huerta, and retired on the Douro.

"Some weeks after (July 21, 1812), this position was again occupied, but being too strong to be attacked in front, the French marched round it, and the battle of Salamanca took place next day, to the right of the ground here sketched, viz., to the right of the village of Arapiles (Z)."

SECTION XX.—RECONNAISSANCE OF A SITE FOR DEFENSIVE WORKS.

555. **Description.**—The object of this kind of reconnaissance is to determine the character and position of the works which are required to defend a given point; and the execution of it presupposes a knowledge of the principles of fortification. The extent of the works must depend upon the importance of the point to be defended, the number of troops available for their defence, and the time at disposal for their construction; these points are decided by the commanding general.

The reconnaissance necessitates a plan of the ground to be occupied by the works themselves, and of the approaches. This plan will be made with more or less care, according to the character of the works to be constructed. For permanent works an accurate map, surveyed with the best instruments, and drawn with great care on a large scale—1″ to 50′—will be required; this is a case of regular surveying, and pertains to the specialty of a military engineer. For temporary earthworks, a Field Sketch, made at leisure with the compass and hand level, will suffice. Indeed it is not always practicable to make even the Field Sketch, as the case frequently arises when the working parties must follow closely upon the heels of the reconnoitring officer. In such cases, the works will necessarily contain many defects, and for the purpose of this instruction, it will be best to take the case when some deliberation is to be used, and when some latitude is allowed as to the number of men to man the works.

556. **Practical Instructions—Field Sketch.**—The principles of fortification being taught elsewhere, and the method of making a Field Sketch having been fully described in the last Section, there remains but little to lay down here.

In practising this kind of reconnaissance the student will be governed by the following instructions. Make a detailed sketch, as described in paragraphs 535–541, 543, 545–548, and 553, of the ground to be occupied by the works and the approaches over which the enemy must advance. Locate upon the sheet all exterior objects that have a bearing on the defence, such as heights, woods, streams, &c. Give the direction of the magnetic meridian, and append a scale of yards constructed from the length of the pace, as described in par. 541.

557. **Points to be Noted.**—Upon a vacant portion of the sheet, make notes upon the following points.

Woods.—Kind and size of timber; whether to be defended, or cleared away, and the labor required to do this (par. 100).

Obstacles.—All natural obstacles, such as marshes, precipices, ravines, &c.; whether they interfere with circulation between the works, with the advance of the enemy, or with the pursuit of him if repulsed; all hedges, stone-walls, defensible buildings, &c.

Materials.—Whether material is at hand for abatis, palisades, and other obstacles (Sect. XVI.); whether an inundation can be formed, and what works will be required for it; what material can be obtained on the spot for revetments (Sects. XI. and XIV.); whether timber can be obtained from buildings, or by felling trees, for platforms, magazines, bomb-proofs, and huts.

Water, &c.—Whether drinkable water is at hand, and in what quantity; same with regard to fuel.

Approaches.—Note the kind of attack which may be expected; whether the ground favors a close approach and then

a sudden attack, or will be thoroughly swept to a long distance; what kind of fire can be brought to bear from different directions, whether artillery or only musketry; the communications to the rear, whether they permit the easy transportation of guns and supplies; whether new roads must be constructed, their position, and the amount of labor necessary to make them.

Soil.—Examine the character of the soil, and ascertain what proportion of picks and shovels will be required in moving it (par. 290); whether it can be readily excavated for planting palisades, torpedoes, &c., or is adapted better to abatis, chevaux-de-frise, &c.

558. **Report.**—The proposed works,—including fortifications, clearings, and roads,—will be located upon the sketch. The report will be mainly a description of these works, beginning on one flank and taking them in sucession. The reasons for each arrangement of detail must be given, thus bringing in most of the points above mentioned. After this description, state briefly the character of the water, fuel, soil, materials, &c., the number of men required to defend each work, and make an estimate of the time required to execute them. State also the number of men who can work to advantage, and the proper proportion of the different kinds of tools. Give the order in which the works should be constructed, supposing that they cannot go on simultaneously, with the reasons therefor.

SECTION XXI.—RECONNAISSANCE OF A ROUTE FOR THE MARCH OF A COLUMN.

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559. **Character of Information to be Obtained.**—In the reconnaissance of a route for the march of a column, the object is to obtain information as to the character of the roads and the nature of the country bordering them, such as will enable a General to definitely arrange beforehand his marches and halts. He must know whether the roads are suitable throughout their length for the troops of all arms which he proposes to send over them; what obstructions he is likely to meet with from the enemy; what places it is proper for each subdivision to halt in, so as to avoid confusion with the preceding or succeeding subdivisions; and what resources in food, water, forage, fuel, and means of defence, these places offer.

560. **How Obtained.**—An officer is sent forward with a small mounted escort over each of the roads leading in the desired direction. He will be required to furnish a sketch of the road, and a detailed report upon the above mentioned points. If near the enemy, he will take the precaution to send before him a couple of scouts, who should always keep within sight of him.

561. In practising this kind of reconnaissance the student will be governed by the following instructions.

Implements.—Each reconnoitrer must be provided with a horse, a watch, a box compass, a field glass, lead pencil, rubber, knife, and a note-book.

562. **Bearings.**—Bearings of the road (par. 539) must be taken at every *general* change of direction, the ordinary sinuosities being sketched in by the eye; bearings should be taken also of all prominent objects within view. If the horse is unsteady, dismount to take bearings.

563. **Measurement of Distances.**—The rate of the horse (par. 542), with the times observed with the watch, will measure the distances. Note the time of starting from a station on a new bearing, and *write it down;* do the same upon arrival at a turn in the road, where of course there is a new station; the difference will be the time between stations. Keep the horse at a walk.

564. **Points to be Noted.**—I. *Nature of the country* and its productions; whether hilly or level; whether the slopes are precipitous and rocky, or gentle; whether the connection of the high grounds is obvious and continued, or if the heights appear detached from each other; general direction of the ridges and which is their steepest side; direction and character of the ravines, whether difficult or easy of passage; what the country produces in the way of grain or cattle; the character of the enclosures, whether stone walls, ditches, hedges, or fences; what parts are wooded, and whether with full grown timber, and what kind of trees.

II. *Streams.* Direction and velocity of current; breadth and depth, and changes they are subject to in various seasons; nature of bed and banks, whether rocky, sandy, or muddy, and their accessibility; the bridges across them, whether of stone or wood, their breadth and length, and whether capable of bearing the weight of artillery; the fords, with similar remarks, and whether always passable or at certain seasons only; the ferries, and nature of landing places, and character and capacity of ferry boats; number and kind of boats on river; whether navigable or not.

III. *Marshes.* Their situation and extent; whether continual throughout the year, and whether passable anywhere for troops.

IV. *Population, &c.* Size of towns; whether well supplied with provisions and horses; character of houses; number of large buildings suitable for hospitals, &c.; whether capable of good defence; whether healthy or not; what number of troops can be accommodated in houses, and what stabling for horses; similar observations with regard to detached farms; the number of carriages, horses, mules, or draught oxen, in possession of each town or farm should be stated.

V. *Roads.* The roads being the most important feature, it is impossible to be too minute in the information respecting them. Observe especially the material and condition of the road-bed; whether fit for artillery, for cavalry, or only infantry; kind of soil it passes over, whether rocky, gravelly, sandy, clayey, or earthy; what injuries it is liable to in bad weather; whether easily repairable, and whether the materials needed for that purpose are at hand; whether any bad part of the road, or the narrow streets of a village, can be avoided by a short detour, as also whether any great improvement could be made in the general direction of any part of the road by adopting a new line altogether for a certain distance, and what amount of work is necessary in either of these cases.

Particular attention should be paid to the ascents and descents, whether easy, abrupt, rugged, stony, having short turns or other difficulties; whether the road is wide enough in those parts which run along the sides of hills, and whether it is even or canted off the level, so as to be unfavorable for wagons.

In those parts where the road passes between walls, or between banks of earth, rocks, or other obstacles, its breadth ought to be measured, and it should be observed whether it can be widened, or the obstacles which confine it removed.

Note also the general width of the road; any obstacle, such

as a small rivulet crossing it; the possibility of obstructing or breaking up the road, or of destroying the bridges and fords upon it, and what means are needed for these objects, with the time and labor required; all branch roads and whither they lead, with the distance off of their termini; the names of localities, spelled correctly and also as they are pronounced.

VI. *Camps and Positions.*—All strong passes or positions, either on the road or within view of it, and all places favorable for a camp; their extent, command, approaches, supply of water and of wood.

565. **Means of Getting Information.**—This information must be obtained as far as practicable by personal inspection; such as cannot be acquired in that manner, may be procured by inquiries from the people of the country or from persons who are familiar with it. Careful distinction must be made between what is learned by personal observation, and that upon the authority of others.

566. **Note-Book.**—The drawing-board with the paper ruled in squares (par. 536) would be useful here, but as these are sometimes inconvenient to carry on a rapid reconnaissance in service, and as their use is a simplification of the present method, the notes will be recorded in a note-book. Upon the left-hand page of this note-book, make a rough sketch of the road, beginning at the bottom and working upwards. Mark each station by a letter, *a*, *b*, *c*, &c. The bearing of the road and the *time* between stations will be written upon the rough sketch. No attempt, in this sketch, will be made to represent the distances and angles with accuracy. Changes of direction will be *indicated*, as also the general direction of objects near, but the written numbers and remarks must be relied upon to furnish the data for the fair copy. Figure 194 will give a notion of the kind of sketch required. Upon the right-hand

page give a full but concise military description of the road and surrounding country. (Fig. 194.)

567. **Fair Copy of the Sketch.**—The fair copy of the sketch will be constructed on a scale of 1 inch to four minutes, the bearings being plotted as described in par. 540. Woods will be colored with a green, water with a blue, and the road itself with a red crayon. In other respects the topography will be represented by the signs shown in Plate I.

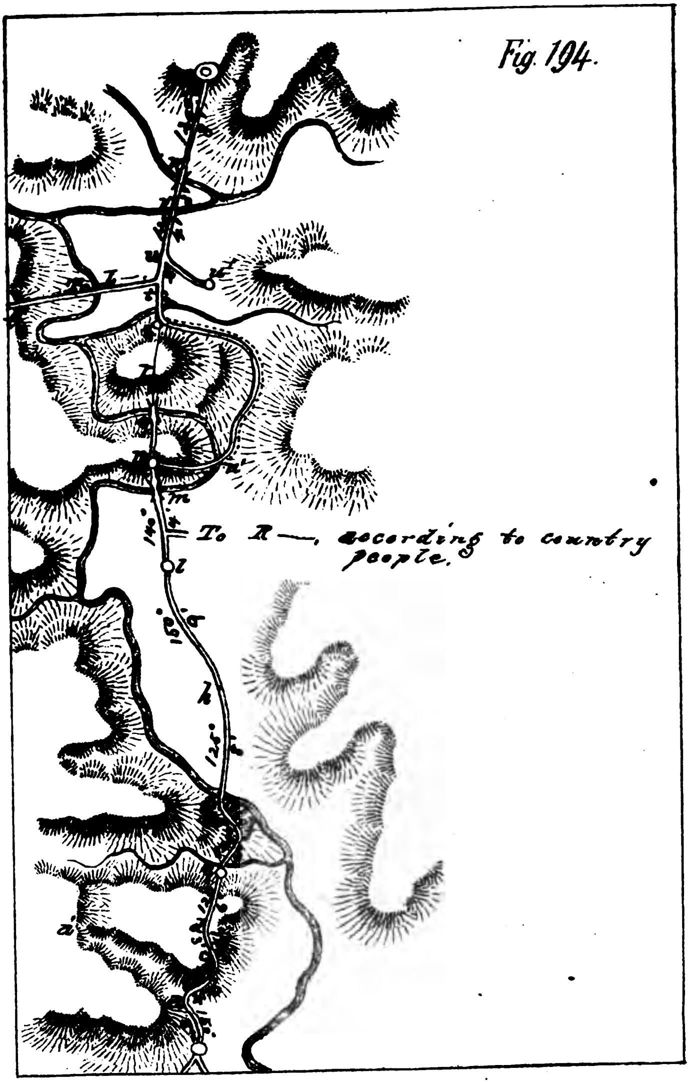
The direction of the magnetic meridian will be given. The names of localities and of isolated houses, will be distinctly marked in printed characters.

After the construction of the sketch, a scale of miles will be appended, obtained from the rate of the horse (par. 542).

568. **Style of the Report.**—The report will contain all the information obtained from the reconnaissance, which is not *clearly* shown on the map, and will employ the fewest words possible consistent with that condition. An inflated style only wastes the time of the General and of the officer himself. What are wanted are hard dry facts, and not patriotic flourishes or flowery descriptions. Great care must be taken however to omit nothing of importance. These important points, brevity, completeness, and clearness, can best be secured by first giving a general outline as an introduction, and then arranging according to their relative importance the different subjects under separate headings.*

* If the communications are numerous and good, a country is said to be *open*. If the accidents of the ground are insignificant, the country is said to be *flat*, or *slightly undulating*; if the accidents are decided and follow each other so as to constantly limit the view, it is *broken*. Although broken, a country may be open and easy, if the roads are numerous and good, the slopes not too steep, and the ground uncovered. Likewise on a plain, the ground may be *difficult*, if it is cut by streams, ditches, hedges, &c.

Fig. 194.



No. 2
Fig. 194

x. Boswell. healthy. well-built town of 4000 inhabitants; about 400 horses & mules. Good water & plenty of fuel, and provisions; woods cover heights. full grown timber: oak hickory, & chestnut.

w. stone bridge. 2 arches. 20' wide 100' long.
v. ford 10 yds wide. unreliable. fascine stuff at hand
u. farm. defensible, 15 horses. hedge enclosures.
t. branch to I—. should be occupied at t. reported good for wagons throughout.

s. to t. deep sandy road. difficult for art.
n. to s. road bad; from o. to s. steep, rocky, & impracticable. can be repaired only with great labor. make detour to right over level gravelly country, crossing river by good ford at n'. always practicable. distance increased ½ mile.

m. to n. road steep but good for all arms.

m. Wooden bridge strong enough for art. 15' wide. 75' long; no material for repair nearer than 1½ mile; ford ½ mile above.
l. Maria (Mar-ree-ah) healthy village. pop 1500. plenty of flour. poultry. beef & pigs; good water; 150 horses & 40 wagons; houses brick; 3 churches & 4 other buildings suitable for hospitals. for 700 patients; defensible; 15000 men can camp on right & left. grass plenty; wood on heights 1½ mile to right.
g. ford 20 yds. wide, 50 yds. long. impassable in Spring; current 6 knots; subject to freshets; bed gravelly; banks precipitous. 6' high, but easily cut down; unnavigable; few boats and those small.
e to g. Woods. dense undergrowth; mostly poplar.
e. rivulet 8" deep; timber at hand for bridge
b to c. road steep. but practicable for art.
b. road excellent at all seasons. rocky bed. 20' wide; bearing ravine aa' 160°. easy for inf. & cav.

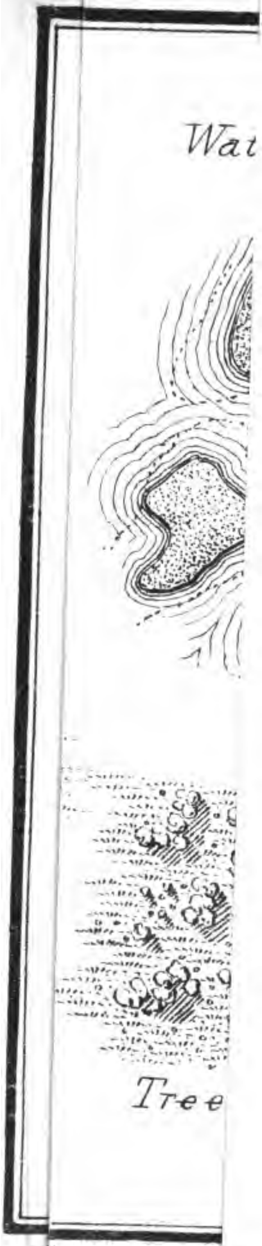
569. **Rules for Writing Report.**—The report will be written upon letter paper, leaving a margin of one-third the width of the page on the left.

Each paragraph will be numbered, and its contents briefly stated in the margin.

When information has been obtained by inquiry, and not by personal observation, it must be so stated.

In arranging the matter the following general indications will be observed. After dating and addressing the report in the usual manner, give the authority and date of the reconnaissance; then state in outline the general character of the country, its communications, resources, population, and military characteristics; and then under the separate headings of Roads, Character of the Country, Streams, Marshes, Population, and Camps, give a detailed account of the points laid down in par. 564.

INDEX.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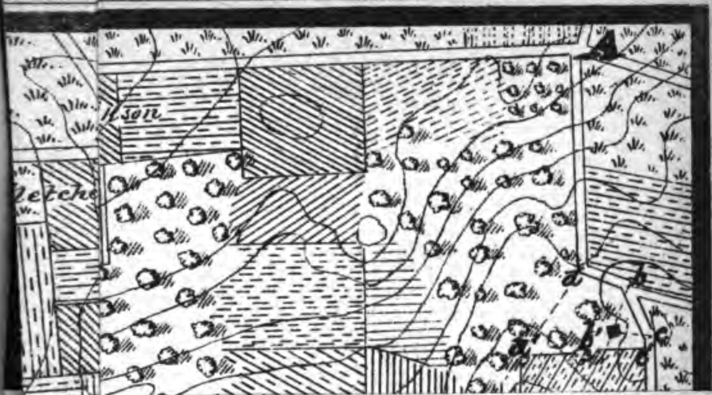

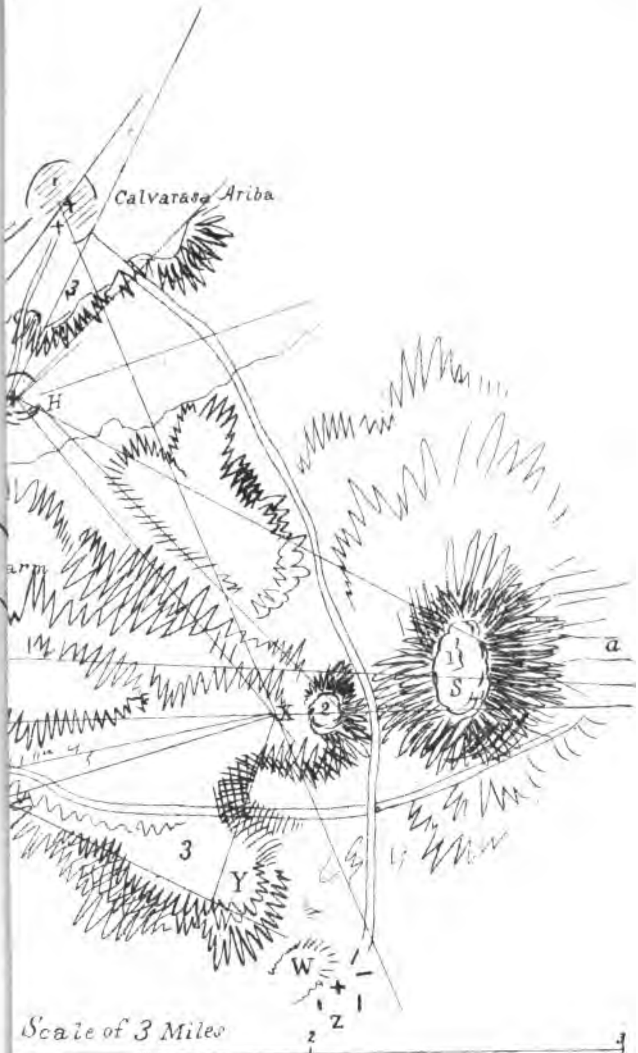
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